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THORACIC AORTOGRAPHY AFTER DIRECT PUNCTURE OF THE AORTA FROM THE JUGULUM

by

Ingmar Wickbom

The great advances in modern cardiac surgery during the last 10—15 years has led to a demand for as detailed as possible preoperative anatomic information. The most satisfactory opportunities for such a study are offered by roentgen examination after contrast filling of the intrathoracic vascular system and by cardiac catheterization. The heart and the pulmonary vessels are best examined after the injection of a contrast medium either into the cubital vein or, by means of a catheter introduced through this vein, directly into the heart. Some investigators also use this method for examination of the aorta, taking films when the contrast medium has reached this region, after having passed through the heart and the pulmonary vessels. As shown by JÖNSSON et al. more accurate information of the true anatomy is obtained if the medium be injected directly into the aorta. The density of the vessel examined in this way is much greater since the contrast medium has not been diluted by passage through the heart and pulmonary vessels; further, the aortic system will not be obscured by medium remaining in the latter. In coarctation of the aorta, the collaterals especially may be more accurately interpreted and, in patent ductus arteriosus, the communication between the aorta and the pulmonary artery more clearly demonstrated. The patent ductus arteriosus itself may often be clearly visualized.

Several methods have been described for contrast injection directly into the aorta. NUVOLI (1936) punctured the ascending aorta through the sternum. RADNER used a similar method in four cases published in 1945. In 1947 he developed the technique of aortic catheterization via

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From Roentgen Department III (Director: INGMAR WICKBOM), Sahlgrenska Sjukhuset, Gothenburg, Sweden.

the exposed radial artery. Retrograde injection into the left common carotid or the left brachial artery has been advised by several authors (Castellanos and Pereiras 1939, Stephens 1948, Freeman 1948 and Burford Carson & Scott 1948). Jönsson (1949) punctured the right common carotid percutaneously with a double cannula, inserting the blunt outer portion into the aorta via the innominate artery. He later abandoned this method because of its technical difficulties and risks, and turned to a technique based on Radner's catheter method. In 1948 Del Campo and Hoyos described a method of puncturing the ascending aorta parasternally. They used this method in four cases without complications. Euler punctured the aorta from the oesophagus during oesophagoscopy. He also evaluated, in cadavers and by animal experiment, the relationship between needle calibre and haematoma formation. On the basis of these experiments he states that the outer diameter of the needle should not exceed the thickness of the arterial wall. According to Hultquist (personal communication) the wall of the ascending aorta is at least 2 mm thick at the age of 20, and increases in size from that period. The risk of causing a haematoma is considerably less if the wall be punctured obliquely.

Since all these methods have certain disadvantages the author has tried another approach to direct puncture of the aorta: *Technique:* The examination is performed with the patient in the supine position, advisably but not necessarily under general anaesthesia. The highest level of the aorta is indicated on the skin. A needle, 12—13 cm long with an outer diameter of 1.8 mm, is used for the puncture. By means of a rubber tube about 2 dm long the needle is connected with a syringe filled with normal saline solution. The puncture is made above the right clavicle just lateral to the common carotid artery (which, as a rule, is easily palpated). The distance from this point to the highest point of the aorta is marked on the needle with a small metal ring which is movable along the needle. The needle is directed almost parallel to the course of the common carotid and the innominate arteries, that is, downwards and slightly to the left and backwards, passing immediately behind the first rib. When the point has passed the rib the aortic pulsations can sometimes be felt against the needle. If not, the needle is gently introduced further in the same direction until the pulsations of the aorta become apparent. If no pulsations be palpable the needle should be withdrawn a little and again pushed forward in a slightly different direction. When searching for the aorta the needle should never be introduced beyond the metal ring. When the pulsations are encountered the needle should be pushed further until the wall of the aorta, which is much firmer than the surrounding tissue, is felt directly under the needle. The pulsations should be emanating from a point slightly to the left of the needle and should be palpable

against it. The wall is then punctured and the needle introduced further, about 1.5 cm, in the same direction; this should be possible without the opposite wall being touched if the needle be in the proper position. To make sure that the needle is well away from the posterior wall it should then be withdrawn about 0.5 cm. During the time needed by the anaesthesist to prepare the patient for apnoea, saline is injected; during the actual puncture it is better to have the syringe disconnected until blood appears freely through the needle. As soon as apnoea is achieved the contrast is injected. We inject 30—40 cc of Dijodon 70 % by hand. The injection time has in most cases been about three seconds. For changing the films we use a casette-changer (manufactured by AB Georg Schönander), which allows us to take ten pairs of films (30 × 40 cm) at right angles to one another in ten seconds.

So far we have used the method in eight cases. The puncture was, in all these cases, performed without any difficulties. Two of the patients developed a mediastinal haematoma which were demonstrated roentgenologically as a mass in the right upper mediastinum. One haematoma was quite small and disappeared completely within two days. The only symptom was a slight 'feeling of pressure' for one day. The other haematoma was larger and required a week for its disappearance. The patient complained of moderate pain and a 'feeling of pressure' behind the sternum, symptoms which gradually disappeared. There was a raised body temperature up to 38° C for about a week. The blood pressure in the right arm was 200—250 mm Hg. The examination, one of our first, was performed under local anaesthesia only, but following it we have always used general anaesthesia. One case had a serious reaction to the contrast injection and died the following day from circulatory insufficiency. This grave complication, which was probably caused by the contrast injection and not by the puncture, is described in detail in another article of this journal (p. 350).

Using the method described the contrast filling of the aorta and its branches will be as good as that achieved by other methods of direct injection into the aorta. The method is simple and is not time-consuming. The disadvantages are the risks of haematoma development and of extravascular deposition of the contrast medium. Since the needle is introduced in the direction of the ascending aorta it is possible to push it further into the lumen than would be possible if the aorta were punctured at right angles through the sternum or parasternally; these methods minimize the risk of the needle's slipping out of the vessel during the contrast injection. The oblique puncture of the wall should also, according to EULER, reduce the possibilities of haematoma development; in order to attempt to lessen that risk still further it is our intention to use a needle of smaller size and to inject the contrast medium by means of a

pressure apparatus. In that way it should be possible, in spite of the smaller calibre of the needle, to introduce the medium with equal rapidity and thus achieve the same density. Since the contrast medium is injected in a retrograde direction, the first part of the aorta will be filled with greater uniformity. Another advantage in comparison with transsternal puncture is the exclusion of the needle and the rubber tube from the examination field and thus from the films. The catheter method, it is true, eliminates the risks of haematomas and extravascular injection. It is however, a much more complicated and time-consuming procedure. Furthermore, the radial artery must be ligatured, a most serious disadvantage of the method, although according to its advocates the ligation should not cause undue distress to the patient. There is no doubt however, that some patients complain of pain and a feeling of coldness and numbness in the hand afterwards. From experiences in surgical departments it is also evident that many patients who had their radial artery cut by accident have similar symptoms, especially if exposed to cold weather (E. MOBERG, personal communication). The same thing is said to happen to some patients who have had blood transfusions through the radial artery. The catheter method cannot usually be used should a further examination be required. JÖNSSON has now abandoned the double cannula method which he developed, because of the technical difficulties and the risks involved. He now uses the catheter method but says in his monography with BRODÉN and KARNELL on thoracic aortography: "It would be as well, however, to have another method in addition to the catheter method, especially when a patient has to be subjected twice to aortographic examination." The present author hopes that the method described in this paper will continue to prove satisfactory and become not only an additional method but the routine technique for thoracic aortographies.

Lastly, some of the films obtained with this method are reproduced in order to illustrate the quality obtained and also to show the correct (Fig. 1) and incorrect position of the needle (Figs. 3 a and b). We are elaborating the procedure further and this paper is merely intended as a preliminary report.

Case 1. E. L., aged 36, was referred for examination because of a systolic murmur to the left of the sternum compatible, but not diagnostic, of a patent ductus arteriosus. Thoracic aortography showed normal conditions. No passage of contrast medium into the pulmonary artery could be demonstrated (Fig. 1).

Case 2. N. S., aged 39. A mass in the mediastinum was revealed on a routine roentgen examination. It could not be distinguished from, and pulsated with, the aorta. Thoracic aortography was performed in order to exclude the possibility of the mass being an aneurysm. No contrast filling of the mediastinal lesion was obtained (Fig. 2).

Fig. 1. (Case 1). Normal appearance of the aorta. The needle is in the correct position.

Fig. 2. (Case 2). Normal appearance of the aorta. There is no contrast filling of the mass seen in the mediastinum to the left of the aorta. To be in a correct position the needle should have been introduced a little further into the aorta.

Fig. 1.

Fig. 2 a.

Fig. 2 b.

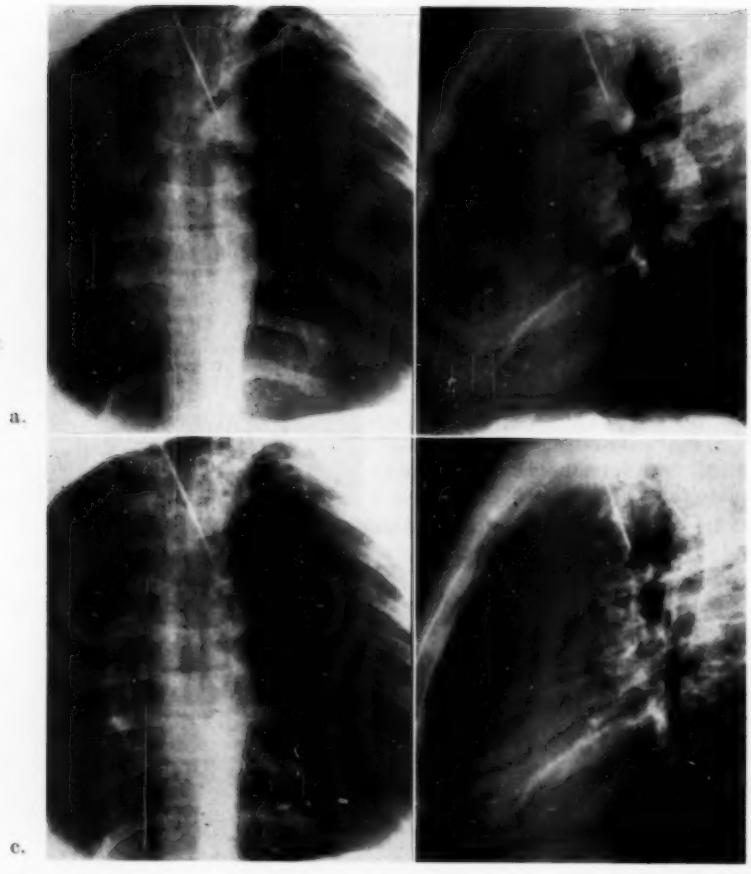

Fig. 3. (Case 3). Coarctation of the aorta with nearly complete stenosis 2 cm below the origin of the left subclavian artery. The collaterals are best seen in c and d which are taken one second later than a and b.

Case 3. B. L., aged 27, had for about a year complained of palpitation and dyspnoea after heavy exertion. B. P. in the arms: 190/110; it could not be measured in the legs. Thoracic aortography revealed coarctation of the aorta (Fig. 3).

SUMMARY

A new approach to thoracic aortography is described, the aorta being punctured percutaneously from the jugulum. The method has certain advantages as compared to other techniques: it is simple and not time-consuming and no vessel is ligatured. The risks of haematoma development and extravascular deposition of the contrast should be minimized if the technique be properly executed.

ZUSAMMENFASSUNG

Ein neuer Weg zur thorakalen Aortographie wird beschrieben: Die Aorta wird perkutan vom Jugulum aus punktiert. Die Methode hat im Vergleich zu früher beschriebenen gewisse Vorteile. Sie ist einfach und nicht zeitraubend. Keinerlei Gefässe sind zu unterbinden. Das Risiko des Auftretens eines Haematomes sowie der extravaskulären Deponierung des Kontrastes dürft bei korrekter Technik minimal sein.

RÉSUMÉ

Description d'une nouvelle voie d'injection pour l'aortographie thoracique: l'aorte est atteinte par ponction percutanée dans la fossette sus-sternale. Cette méthode présente par rapport à celles qui ont déjà été décrites certains avantages: elle est simple et rapide, ne nécessite pas de ligature de vaisseau. Les risques d'hématome et d'injection de contraste hors des vaisseaux devraient être réduits si la technique est utilisée correctement.

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FROM ROENTGEN DEPARTMENT III (DIRECTOR: INGMAR WICKBOM), SAHLGRENSKA SJUKHUSET, GOTHENBURG, SWEDEN

DEATH FOLLOWING CONTRAST INJECTION INTO THE THORACIC AORTA

Case Report

by

Ingmar Wickbom

The contrast media used nowadays for angiocardiographic examinations are almost all composed of 3, 5 diiodo-4-pyridine-N-acetic-dietanolamin. The preparation is marketed under names such as Umbradil, Pyelosil, Diodrast, Dijodon and Perabrodil. It has many advantages but is not ideal, mainly because of its irritating effect on the arterial wall. Chemically, the types of preparation are certainly the same but the irritating effect doubtlessly varies with different products and depends apparently on their purity. The substance causes (at least in small vessels) vasoconstriction followed by dilatation. BROMAN and OLSSON have shown in animal experiments that the wall of the cerebral vessels may be temporarily damaged by the contrast medium causing a breaking down of the blood-brain barrier. This damage is clinically illustrated by severe reactions, even deaths, following cerebral angiographies. There are also cases reported in which injection of highly concentrated contrast media into the mesenteric artery and other branches of the abdominal artery of similar size has proved fatal. Judging from the literature however, it seems that the heart and the aorta tolerate even highly concentrated contrast substances of the type fairly well. According to ROBB and STEINBERG Diodrast 70 % used in angiocardiography causes an increase of the pulse rate of approximately 30 beats per minute and often a fall in arterial blood pressure rarely exceeding 30 mm Hg. Severe vomiting, pallor and hypotension occurred in some cases but the reaction was usually over after a few minutes. Electrocardiograms made in 28 patients showed significant changes in only one instance: A man aged 71 who had previously had a coronary occlusion, developed a further occlusion 30

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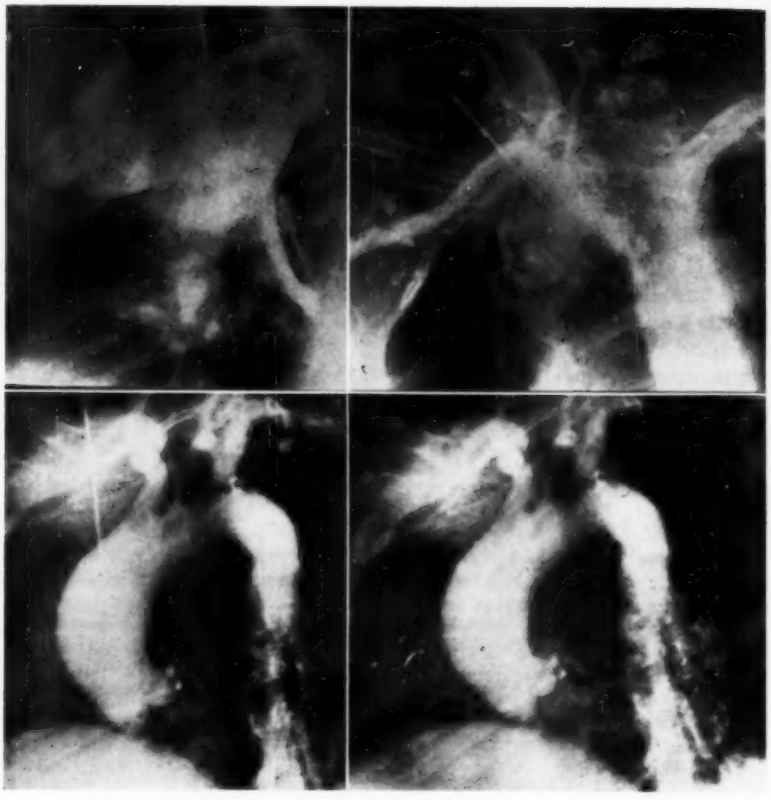
hours after the injection. Apart from that case no serious complication occurred. Neither did BIÖRCK, SYLWAN and LINDBLOM-TILLMAN find any serious changes in electrocardiograms made during thoracic aortographies performed by JÖNSSON at Södersjukhuset, Stockholm. They observed a bradycardia which lasted 2—4 seconds after the injection and which was followed by a gradually increasing tachycardia for about a minute. Even in a case in which the tip of the catheter lay in the coronary artery no significant changes were found. NUVOLI used 28 cc of a 100 % solution of sodium iodide. When the injection was made directly into the left ventricle of the heart (after percutaneous puncture) the patient collapsed. Thirty hours later he had still marked bradycardia and a severe headache. When the same amount was injected into the ascending aorta the patient experienced only slight discomfort.

Thus injection of highly concentrated contrast media of the types mentioned into the heart or the aorta is usually well tolerated. That was also true in 7 of the 8 cases performed by the author with the technique described in Acta Radiologica (page 343). In one case however, which will now be described in detail, a severe complication occurred and led to the death of the patient.

The patient was a woman aged 66. Twenty-three years previously she had had roentgen treatment for goitre. She had been very nervous for many years, and for two years previously complained of dyspnoea and heart palpitations. One year previously she observed a lump in the jugulum which had gradually increased in size since then. On examination she was found to be very nervous but otherwise in fairly good condition. No murmur heard over the precordium. B. P.: 240/140 mm Hg. Over the manubrium of the sternum a pulsating mass measuring 5 × 6 cm was palpated. Roentgen examination of the sternum revealed extensive destruction corresponding to the mass. An angiography of the innominate artery was performed in order to discover the true nature of the process. A highly vascular tumour, the size of an orange, containing numerous wide tortuous vessels and mainly fed by the internal mammarian artery, was shown (Fig. 1). In spite of the patient's age and high blood pressure it was considered that the tumour, because of its apparent malignancy should, if possible, be removed. When planning the operation, however, the surgeon desired to know the exact position of the tumour in relation to the aorta, and also whether any more vessels contributed to the vascular supply of the tumour. For that reason aortography was performed after direct puncture of the aorta from the jugulum. The examination was carried out under general anaesthesia. The aorta was punctured without difficulty and any reaction by the patient. After 2—3 minutes, during which time the anaesthetist prepared the patient for apnoea, 30 cc of Dijodon 70 % was injected in about 3 seconds. After the injection the pulse was found to be rapid and feeble. The blood pressure was 80 mm Hg. After stimulation the patient partly recovered: the pulse was better and the blood pressure rose to 100 mm Hg. An E. C. G. was made but could not be interpreted in detail because of the tachycardia (200 beats per minute). The stimulation was continued but the patient never recovered completely and died the following day, apparently from circulatory insufficiency.

Post mortem examination (HULTQUIST): In the manubrium of the sternum there was an orange-sized tumour with irregular processes extending towards the right hilum and the heart. The fat tissue of the mediastinum was infiltrated causing compression of the



1 a. 1 b.

2 a. 2 b.

Fig. 1. Angiography of the innominate artery. A vaguely defined, highly vascular tumour, mainly fed by the internal mammarian artery, in the right upper part of the mediastinum. Extension through the manubrium of the sternum with irregular processes towards the heart.

Fig. 2. Thoracic aortography after direct puncture. Note the position of the needle in *a*. In *b*, taken 7 seconds later, the coronary arteries are still filled with contrast medium.

great vessels especially the veins. Some extravasations were noted in the tumour but no changes that could be ascribed to the puncture. Microscopically the tumour was found to be a malignant goitre (Langhans Wuchernde Struma). The thyroid was the size of a tangerine and had no connexion with the tumour. The pericardium contained 250 cc of yellowish red fluid and a thin blood clot.

There was moderate hypertrophy of the left ventricle and small petechiae under the endocardium but otherwise no significant changes were seen in the heart. Arteriosclerosis of a moderate degree of the aorta and the coronary vessels was present.

There seems to be no doubt that the fatal outcome was caused by the examination. As the reaction occurred, not in connexion with the puncture, but only after the contrast injection and as no haematoma attributable to the puncture was found at post-mortem it seems fair to conclude that the fatality was due to the contrast injection rather than to the puncture. The aorta and its branches, coronary arteries included, are seen in the films to be well filled with contrast medium. The contrast filling remains more or less the same in all the films, the last two being taken 7 seconds after the first and 3—4 seconds following the injection. All the films also appear to have been obtained in diastole, the aortic bulb being well filled with contrast medium in each case. From this it may be concluded that there was no heart action for at least 7 seconds. Under these circumstances it seems very likely that damage of the myocardium may have resulted partly from ischemia and partly from the contrast substance in the coronary artery. The compression of the great veins caused by the tumour may also have contributed to the disturbance of the circulation.

The following conclusions may be drawn from this case:

1. The negative result of the autopsy, as far as any damage caused by the puncture is concerned, supports the opinion that the author's method of direct puncture of the aorta from the jugulum is a practicable method.

2. Highly concentrated contrast media of the Diodrast type, although well tolerated by the aorta in most cases, may, if remaining in the coronary vessels for long, cause ischemia of the myocardium. Thoracic aortography should be avoided therefore, if a slow circulation time be suspected.

SUMMARY

A case is reported in which death followed thoracic aortography after percutaneous puncture of the aorta from the jugulum. There was a serious reaction to the contrast injection but none to the puncture; at autopsy no damage, attributable to the latter, could be found. The author is of the opinion that the fatal outcome was due to the contrast medium, which remained in the coronary arteries for at least 7 seconds, rather than to the puncture.

ZUSAMMENFASSUNG

Ein Todesfall im Anschluss an eine thorakale Aortographie vom Jugulum aus wird berichtet. Der Patient hatte eine schwere Reaktion auf die Kontrastinjektion, reagierte jedoch nicht auf die Punktion. Bei der Autopsie konnte keinerlei auf die Punktion zurückführbare Schädigung gefunden werden. Der Verf. ist der Ansicht, dass der tödliche Ausgang eher durch das Kontrastmittel (70 %) Dijodon, das mindestens 7 Sekunden in den Kranzarterien verbleibt, verursacht ist als durch die Punktion.

RÉSUMÉ

L'auteur rapporte un cas de mort consécutive à une aortographie thoracique par ponction percutanée de l'aorte en partant de la clavicule. Le malade réagit fortement à l'injection de contraste mais non à la ponction. A l'autopsie on ne put voir aucune lésion imputable à la ponction. L'auteur pense que l'issue fatale est due au contraste (Diodone à 70 %) qui resta dans les artères coronaires pendant au moins 7 secondes.

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FROM THE DEPARTMENT OF CELL RESEARCH (DIRECTOR: PROFESSOR T. CASPERSSON), KAROLINSKA INSTITUTET, STOCKHOLM, SWEDEN

THE ACCURACY OF CYTOLOGIC MASS DETERMINATION BY ROENTGEN ABSORPTION

by

B. Lindström

The weight of cytologic structures may be calculated from absorption measurements of continuous, soft, filtered Roentgen rays in histologic tissue sections, 5—10 μ thick (ENGSTRÖM and LINDSTRÖM 1950). The procedure is based on the fact that the carbon, nitrogen and oxygen in the tissue make the highest contribution to the absorption of soft Roentgen rays. These elements, taken in the same proportions as in proteins, are therefore assumed to be responsible for the total absorption. The composite mass absorption coefficient for this mixture is $\left(\frac{\mu}{\varrho}\right)CNO_p$ $cm^2\ g^{-1}$. Naturally this approximation introduces a systematic error, since there are other elements in the tissues with mass absorption coefficients both higher and lower than $\left(\frac{\mu}{\varrho}\right)CNO_p$. The limit concentrations of these other elements (H, Na, Mg, P, S, Cl, K, Ca, Fe and C, N and O in non-protein molecules) are calculated for a systematic error of $\pm$ 5% in the weighing procedure. In ordinary tissues hydrogen is the only element that exceeds the limit concentration; for it, therefore, a correction factor, k_{H_p}, is included.

A microradiogram of the thin biologic sample and a reference system (*e. g.* a step wedge of nitrocellulose foils) is registered on a fine-grained photographic film emulsion. The sample and the reference system must be in close contact with the emulsion and the mass absorption coefficient of the reference system, $\left(\frac{\mu}{\varrho}\right)CNO_{ref}$, have the same wavelength

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dependence as $\left(\frac{\mu}{\varrho}\right)\mathrm{CNO}_p$. The microradiogram is enlarged by photomicrography, and the absorption of the reference system and of the various cytologic structures is then registered with a photometer.

The mass of a cytologic structure per unit area is given by the following formula (ENGSTRÖM and LINDSTRÖM 1950; equation 10 a):

$$\frac{m_a}{k_{H_p}} = \frac{k_{H_{ref}}}{k_{H_p}} \cdot m_{ref} \cdot \frac{\left(\frac{\mu}{\varrho}\right)\mathrm{CNO}_{ref}}{\left(\frac{\mu}{\varrho}\right)\mathrm{CNO}_p}.$$

$\frac{m_a}{k_{H_p}}$ is the mass of the cytologic structure, $k_{H_{ref}}$ and k_{H_p} are the correction factors for hydrogen in the reference system and the cytologic structure respectively, and $\left(\frac{\mu}{\varrho}\right)\mathrm{CNO}_{ref}$ and $\left(\frac{\mu}{\varrho}\right)\mathrm{CNO}_p$ are as defined above (calculated at the same wavelength). $m_{ref} = u \cdot w$, where u is the foil equivalent of the cytologic structure, determined by comparing the

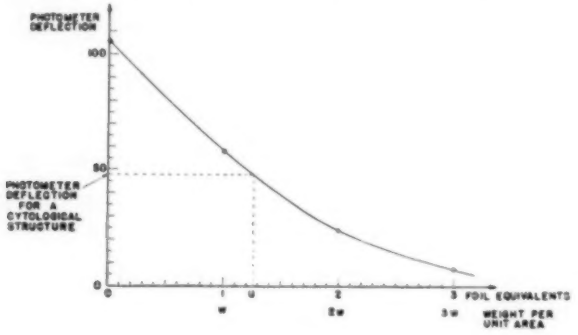

Fig. 1.

photometer deflection for the structure with the calibration curve of the step wedge (see fig. 1), and w is the weight per unit area of one foil (weighed on a microbalance).

Thus, when evaluating the accuracy of the method, the following four factors must be considered:

$$1)\ k_{H_p} \cdot \left(\frac{\mu}{\varrho}\right)\mathrm{CNO}_p;\quad 2)\ k_{H_{ref}} \cdot \left(\frac{\mu}{\varrho}\right)\mathrm{CNO}_{ref};\quad 3)\ u;\quad 4)\ w.$$

1) $k_{H_p} \cdot \left(\frac{\mu}{\varrho}\right)\mathrm{CNO}_p$ is the corrected mass absorption coefficient for the cytologic structure in question. The systematic error of the method de-

pends on the fact that other elements in the tissue have $\frac{\mu}{\varrho}$ of different values, compared with $\left(\frac{\mu}{\varrho}\right)CNO_p$, but the integratal effect of these other elements (with the exception of hydrogen) is rather small. k_{H_p} is introduced in order to correct for hydrogen that has too low a mass absorption coefficient, compared with the mean $\left(\frac{\mu}{\varrho}\right)CNO_p$. With this correction the systematic error is less than ± 5 % in ordinary soft tissue. Thus the upper limit of the error of $k_{H_p} \cdot \left(\frac{\mu}{\varrho}\right)CNO_p$ is smaller than ± 5 %.

2) $k_{H_{ref}} \cdot \left(\frac{\mu}{\varrho}\right)CNO_{ref}$ is the corrected mass absorption coefficient for the reference system. Since an accurate elementary analysis of the reference system has to be performed, and since a small error in the analysis gives a still smaller error in $k_{H_{ref}} \cdot \left(\frac{\mu}{\varrho}\right)CNO_{ref}$, the error of this expression is very small in comparison with the error of $k_{H_{ref}} \cdot \left(\frac{\mu}{\varrho}\right)CNO_p$. As the ratio $\frac{k_{H_{ref}} \cdot \left(\frac{\mu}{\varrho}\right)CNO_{ref}}{k_{H_p} \cdot \left(\frac{\mu}{\varrho}\right)CNO_p}$ is required and not the absolute values of the two factors, the errors of $\frac{\mu}{\varrho}$, taken from the tables, may be neglected. Thus the resulting systematic error of this ratio, including both factors, may be fixed at ± 5 %.

3) Various experimental factors contribute to the error of u. There are inhomogeneities in the photographic film emulsion, a problem recently discussed (ENGSTRÖM and LINDSTRÖM 1951). The roentgen ray incident upon the biologic sample and the reference system should possess uniform intensity; by reason of the fact that the electron bombardment changes the surface of the anode, this must frequently be checked. When the microradiogram is enlarged by photomicrography, the cytologic structure and the reference system are photographed on the same plate with stabilized illumination and constant exposure time; otherwise the ratio between the density values in the original microradiogram is changed, and no quantitative data obtained. The accuracy of the photometric deflection for a histologic structure depends on the size and homogeneity of the structure in question. Structures with areas smaller than about 5 μ^2 should not be measured. By means of the calibration

curve of the step wedge the photometric deflections are transformed to foil equivalents, u. The absorption of each foil in the step wedge must be smaller than that of the tissue section with a sufficient number of steps present to cover the whole absorption range of the sample.

In order to estimate the error introduced by all these factors, the standard deviation of the differences of 35 duplicates has been calculated. The same step wedge was used within a duplicate. When the standard deviation of the differences is divided by $\sqrt{2}$, the error of a single determination of u is obtained. With the technique described above this amounts to ± 23 % for cytoplasms of nerve cells, which were used as test material. This figure also includes certain biologic variations *e. g.* the inhomogeneity of the object (ENGSTRÖM and WEISSBLUTH 1951). The inhomogeneity of tissue varies for different material and fixation methods.

4) The technique of making foils for the reference system has been as follows. 10—20 drops of a diluted zapon varnish solution are floated on the surface of distilled water in a clean round glass dish, about 8—9 cm in diameter, in the bottom of which lies a round metal ring, about 6 cm in diameter. When the zapon varnish begins to wrinkle, the metal ring is raised above the surface of the water. After drying an even unwrinkled foil of zapon varnish, suspended in the metal ring, is obtained. A known area of each foil is cut out and weighed on microbalance. This and adjacent parts of the foil are used in the step wedge as a reference system. The appropriate weight of the foil is $0.2 - 0.5$ mg cm^{-2}, when ordinary tissues are investigated and the sections are $5 - 10\ \mu$ thick.

Three factors are of importance in estimating the accuracy of w: the error in determining the area of the part of the foil to be weighed, the weighing procedure, and the homogeneity of the mass distribution over the area of the whole foil. The resulting error of w has been determined from the standard deviation of 21 duplicates in the same way as for u above. The error in a single determination of w then amounts to ± 11 %.

Thus the absolute weight per unit area of a cytologic structure has a total error which is composed of four partial errors; two of these together amount to ± 5 %, and the remaining two to ± 23 % and ± 11 % respectively. These errors are combined in the formula for relative errors of a product: $\pm \sqrt{5^2 + 23^2 + 11^2} = \pm 26$ %, which is the total error of the method, obtained in an average biologic material.

Three characteristics of the method need further consideration:

1) The weight per unit volume is calculated by dividing the absolute weight per unit area with the thickness of the section. The error of the determination of the thickness therefore increases the final relative error in this case.

2) In extraction and digestion experiments a repeated mass determination makes it possible to calculate the mass of material removed. The error of the calculated difference is influenced by two measurements. Small differences are therefore unreliable.

3) In many cases it is interesting to know the relative distribution of mass in various cytologic structures. The error of w then disappears and that of u is reduced as some of the factors, contributing to this error, do not influence the ratio between the masses of structures lying close together in the same biologic sample. Thus, in a certain series of experiments the ratio between the masses per unit area of the anisotropic and isotropic bands of striated muscles from Chironomus is 1.65 : 1 with a standard deviation of about $\pm$ 11 %. This figure includes the variation of the biologic material, and therefore the experimental error of a single determination is smaller. The total error in this case is $\pm \sqrt{5^2 + 11^2} = \pm 12$ %.

When investigating structures particularly favourable to the roentgen weighing procedure the accuracy is higher. Thus the total mass per unit volume in the myelin sheath of single nerve fibers was determined with a standard deviation of $\pm$ 23 % (Engström and Lüthy 1950). This figure includes the biologic variation between the different fibers and the determination of the thickness.

Possible improvements of the method are being investigated. The accuracy will increase when the photographic detecting system is replaced by an electrical one, making a reference system unnecessary. The roentgen microscope (Kirkpatrick and Baez 1948), when available, will make it easier to define the particular area measured with these electrical detecting systems. If a continuous spectrum, consisting of roentgen rays still softer than those now used, be utilized, the contrast increases and therefore the method will gain in sensitivity and accuracy. The modified theory and a description of the experimental equipment will be published shortly.

SUMMARY

The accuracy of cytologic mass determination from Roentgen absorption measurements in thin biological samples is evaluated. The various partial errors are investigated and possible improvements discussed.

ZUSAMMENFASSUNG

Die Genauigkeit der zytologischen Massenbestimmung durch Röntgenabsorptionsmessungen in dünnen biologischen Schnitten wird beurteilt. Die verschiedenen Fehlerquellen werden untersucht und Verbesserungsmöglichkeiten werden diskutiert.

RÉSUMÉ

L'auteur étudie la précision de la determination de la masse cellulaire au moyen de mesures d'absorption des rayons Roentgen par des préparations biologiques minces. Il recherche les causes d'erreurs partielles et discute les perfectionnements possibles.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR AT THE TIME OF THIS INVESTIGATION: PROFESSOR Å. ÅKERLUND), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

A SIMPLE TECHNIQUE FOR SIMULTANEOUS SCREENING AND RADIOGRAPHY

by

Ove Mattsson

It is most desirable on occasions to be able to study the screen image of an organ of a patient up to the very instant of the radiographic exposure. The latter may then be made at the most appropriate moment, so that the appearances may be depicted in their most characteristic phase. This is of particular value during the examination of certain parts of the digestive tract and has led to the construction of apparatus in which the film cassettes are brought into position and exposed by the light movement of a lever. Mention must here be made of an apparatus suggested by LINDGREN (1941), which permits radiography in immediate connection with screening. A recent construction is the Scopograph, produced by Philips Ltd. Devices of this type are well suited, for example for ventricular and duodenal examinations. For very rapid processes, however, they will not permit of sufficient speed, and for which filming of the screen image, or high-speed serials, will perhaps be the answer. At the Sixth International Congress of Radiology, July, 1950, excellent presentations of anatomic and physiologic processes as applied to diagnostic problems were provided by means of cine film. The distinctly recorded web-like indentations of the oesophagus in Plummer-Vinson's syndrome were remarkable (Year Book of Radiology, 1951). As regards film changing, I should like to mention the device for roll film constructed by GIDLUND: A recent model, giving 8 exposures per second, and designed for angiocardiography, appears to have many other uses; the film strips produced are almost ideal — but they require expensive special apparatus and consume large amounts of material.

Swallowing is a process which it is valuable to be able to depict faithfully. Films produced with a maximum of contrast filling of the

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lower hypopharynx and upper part of the oesophagus may reveal the valvular-like filling defects which have been described in detail by KJELLBERG and WALDENSTRÖM, and stated to be connected with sideropenous anaemia (Plummer-Vinson's syndrome). These small indentations cannot be identified except on films exposed with a maximum filling of the regions. The changes have attracted additional attention through the fact that they are believed to indicate a predisposition to cancer of the hypopharynx (AHLBOM 1937, JACOBSSON 1951).

Films with contrast filling of the hypopharynx and upper part of the oesophagus may, according to KJELLBERG and WALDENSTRÖM, be made by counting aloud. The operator slowly counts "One, two", — the patient is instructed to swallow on "three" — and the exposure made on "four". The field may be observed directly on a fluorescent screen behind the cassette, and which is illuminated during the exposure. Appropriate tempo and routine are tried out in every case by directing the patient to swallow and observing the process on the screen. Faulty exposures are detected and repeated immediately. Another method consists in studying the external movements of the larynx and exposing the film at the very moment when the larynx is in a position which indicates that it is filled with the desired amount of contrast medium; this is best learned by experience. Sometimes the larynx is also palpated with the finger so that the movement may be felt, but this method must be regarded as unsuitable in view of the radiation danger to the operator. The methods last mentioned are all unreliable, inter alia because they require a good deal of co-operation of the patient. More than one series of films must usually be made in order to secure a perfect result; furthermore, the patients mostly have difficulty in swallowing, which does not make the matter any easier.

A continuous energization of the fluorescent screen enabling the radiographic exposure to be made when a suitable degree of contrast filling is observed, appears to offer a solution to the problem. The exact instant for the exposure may thus be chosen — the desired phase selected and only sufficient contrast filling depicted. This method saves time as well as film and is more pleasant for the patient.

The equipment generally available in an ordinary radiographic clinic will permit simultaneous screen observation and exposure, and includes the use of two tubes placed at an angle to one another. Only a few small technical modifications are required.

A mobile dental unit of conventional type is equipped with a separate milliampere control for screening consisting of a rheostat which regulates the filament voltage of the tube. Of course occasional direct use of the unit is possible without the supplementary controls for the short periods of screening required in these examinations. It may be

shown that the time required — usually less than 30 seconds in all for a "swallow" examination — cannot produce any considerable radiation dosage provided an adequate tube-skin distance (about 24 inches) and a small diaphragm are used.

The principle of the arrangement is shown in Fig. 1. The central rays of the tubes are set at an angle of 90 deg. to one another: the p. a. view is thus observed on the screen while the lateral is projected and exposed and vice versa. A crossed Lysholm grid is used to reduce the

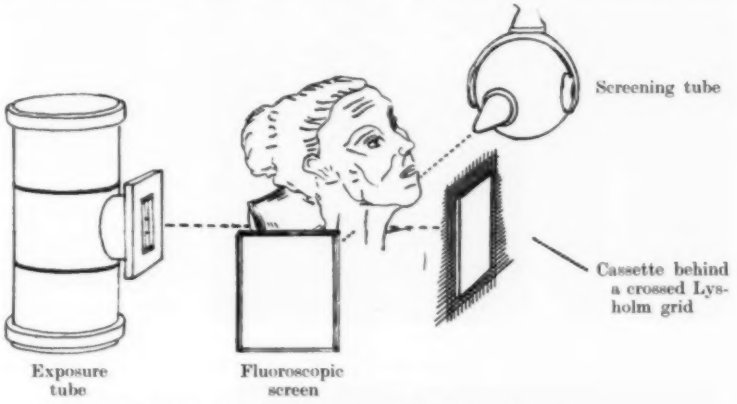


Fig. 1. Principle of the arrangement for simultaneous screening and radiography.

effect of secondary radiation on the film during the screening period. The examination is carried out as follows: The patient is placed in a comfortable position, preferably with the head supported by a pillow, and is given a large mouthful of the contrast medium which he is asked to retain in his mouth until further directions are given. A loaded cassette is placed in position. The room lights are extinguished and radiation at right angles is switched on for screen observation during the swallowing process. The observer is protected by a lead screen and is able to study the screen image in detail through a lead glass window. The layout of the assembly is shown in Figs. 2 and 3. If the radiographic room and adjoining cubicles be suitably arranged, the observer may remain outside the room and carry out the examination through a fixed lead glass window. The controls for the screening and the exposure are conveniently placed: the latter consists of a switch with a pistol grip designed to fit the hand and permits very rapid operation. Figs. 4 a—e show a series of films of the act of swallowing in the same patient, obtained by the arrangement. The same phase of swallowing was chosen

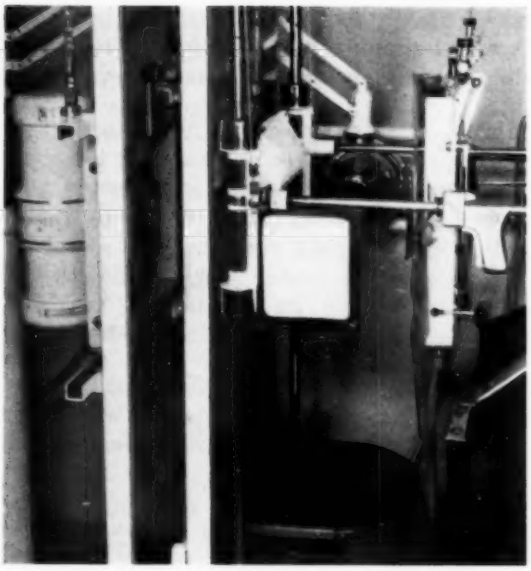


Fig. 2. Arrangement for swallowing examination with simultaneous screening and radiography. The patient is placed in a comfortable position with the head supported by a pillow.

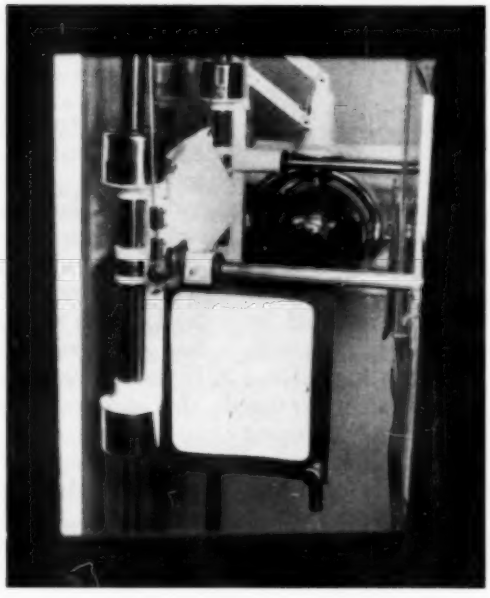
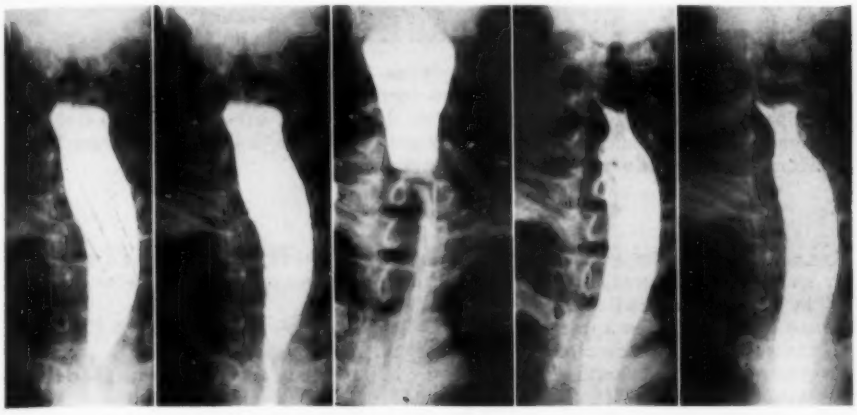


Fig. 3. The observation screen as seen through the lead glass.



a. b. c. d. e.

Fig. 4. A series of films of the act of swallowing in the same patient. The first two (a, b) were exposed in the same phase of swallowing as observed by simultaneous screening. Note that the precise moment of exposure may be selected. In the other films earlier and later phases were chosen.

for the first two projections (a, b) which illustrate how accurately the moment of exposure may be determined by simultaneous screen observation. In the other films an earlier (c) and a later (d, e) instant of exposure were chosen. The views show normal conditions, but there is a slight curved displacement of the upper part of the oesophagus toward the left.

The method described is admirably suited for the study of the process of swallowing but it might possibly be used in other fields for the purpose of depicting a particular phase of rapid movement.

SUMMARY

The author describes a simple technique for simultaneous radioscopy and radiography utilizing the ordinary equipment of the roentgen department. The method is particularly suitable for "swallow" examinations, especially when Plummer-Vinson's syndrome is suspected. Films showing maximal contrast filling of the upper oesophagus are easily produced.

ZUSAMMENFASSUNG

Der Verf. beschreibt eine einfache Technik für gleichzeitige Durchleuchtung und Bildaufnahme bei Anwendung der gewöhnlichen Apparatur der Röntgenabteilung. Die Methode ist besonders nützlich für Schluckuntersuchungen, insbesondere wenn Verdacht auf Plummer-Vinsons Syndrom besteht. Röntgenaufnahmen mit maximaler Kontrastfüllung des oberen Teiles des Ösophagus können leicht hergestellt werden.

RÉSUMÉ

L'auteur décrit une technique simple de radioscopie et de radiographie simultanées utilisant l'appareillage ordinaire des services de radiologie. Cette méthode convient particulièrement pour les examens "en déglutition", surtout quand on recherche un syndrôme de Plummer-Vinson. On obtient facilement des images de remplissage maximum de la partie supérieure de l'oesophage.

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FROM THE 1ST ROENTGEN DEPARTMENT (DIRECTOR: DOCENT GUNNAR JÖNSSON),
SÖDERSJUKHUSET, STOCKHOLM, SWEDEN

NOTES ON THE TECHNIQUE IN PHLEBOGRAPHY OF THE THIGH

by

Per Ödman

During recent years, roentgenologic and surgical attention has been increasingly directed to the pathologic changes in the venous system of the thigh. A conception has been formed of the great significance of the rôle played by these veins in lower leg conditions. In important pioneer investigations, BAUER, SYLWAN, LUKE et al., have shown that a phlebographic study by the retrograde injection of contrast medium into the common femoral vein is essential for the demonstration of pathologic changes in the veins. The phlebographic observations frequently afford decisive therapeutic indications.

However, retrograde phlebography by the percutaneous injection of contrast medium into the common femoral vein, as described by LUKE, SYLWAN et al., is not entirely satisfactory; among other reasons is the fact that the hands of the operator are exposed to strong radiation. The contrast medium is also sometimes injected extravascularly in this method, making the results of the examination uncertain and causing the patient discomfort. BAUER carries out retrograde phlebography by the injection of contrast medium into the common femoral vein after its exposure on the operating table. The risk of extravascular injection is not great with this method, but, for many reasons, the roentgenologic technique is likely to be faulty and the reliability of the results questioned.

STÜRUP and HØJENSGÅRD (1950) used a special puncture procedure for the measurement of the pressure in the veins of the thigh. It is described as follows: "Through a needle, percutaneously puncturing the external saphenous vein in its subcutaneous course, we introduced a venous

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catheter for a sufficient distance into the vein, so that the opening in its tip reached the popliteal vein or the most distal part of the femoral vein. The needle was then withdrawn over the catheter . . ."

Since September, 1951, we have used a method after the same principles both for retrograde phlebography by the injection of contrast medium into the common femoral vein and for phlebography by the injection of contrast medium into the popliteal vein. The vein is percutaneously punctured with a needle approximately 12 centimeters in length, under a local anaesthetic. Through the needle, a fine polyethylene catheter (internal diameter, 0.6 millimeters), about twice the length of the needle and of sufficient thickness to fill the bore without permitting leakage, is introduced. The catheter is threaded on a somewhat shorter, straight, steel wire ('leader') (Fig. 1). By this means, it is possible to direct the catheter to some extent, so that it does not become entangled within the lumen of the vein or come to rest in a lateral branch. The next step is the removal of the 'leader' and the needle, while the fine polyethylene catheter remains in the vein and is then connected to a similar catheter of the desired length. The system is continuously flushed with physiologic saline solution. This arrangement affords great advantages: the patient may be examined in almost any position, the leg rotated between exposures in order that suitable projections may be obtained, and the operator injecting the contrast medium may stand behind a protective lead screen during the whole investigation.

Fig. 1. (Schematic) Catheter with 'leader' introduced through the puncture needle.

The examination is carried out on a tilting roentgen couch. Through a simple coupling arrangement, the tube and cassette are co-ordinated, so that the target-film distance remains unchanged when the cassette holder is moved up and down the couch or when the latter is tilted at different angles. Moreover, the tube can be rapidly directed towards the cassette (Fig. 2). Because of this, anteroposterior films may be taken in rapid sequence with the Potter-Bucky diaphragm and at a constant distance; this is of great importance, especially as regards the film quality. In the same manner, films may also be taken with the leg rotated so that different projections are obtained. Lateral views are taken with another tube without secondary filtration.

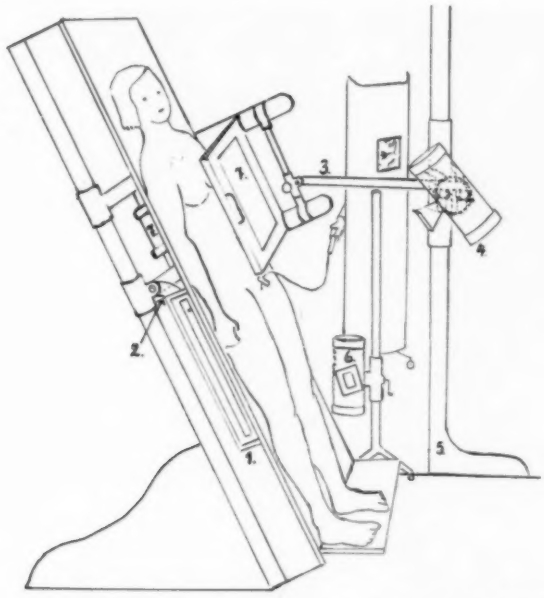
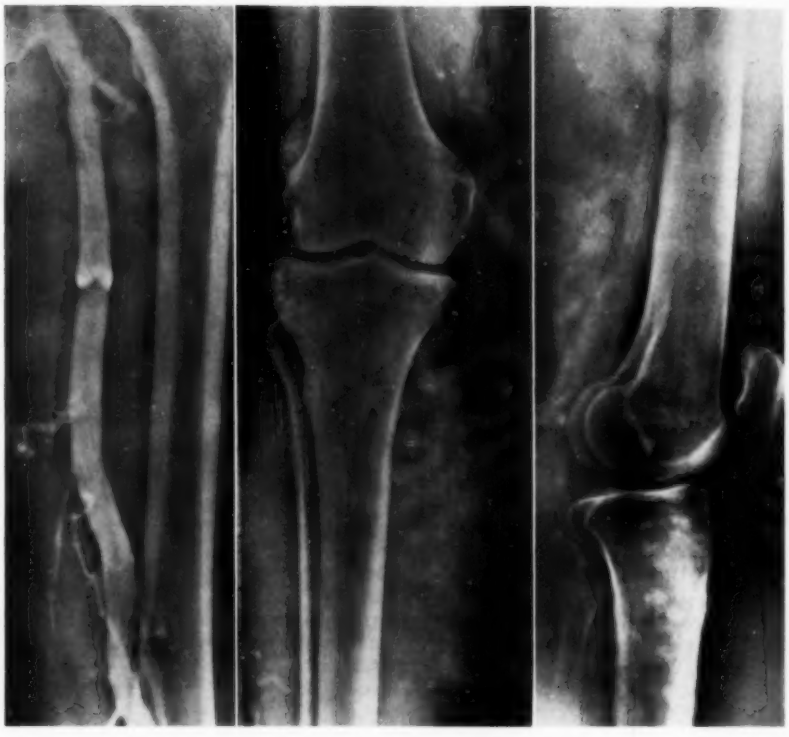


Fig. 2. (Schematic) Apparatus for phlebography. 1. Cassette holder. 2 and 3. The connective devices which co-ordinate the tube and cassette holder. 4. Roentgen tube for a. p. projection. 5. Ceiling-floor tube stand. 6. Roentgen tube for lateral projection. 7. Trochoscope with fluoroscopic screen.

In retrograde phlebography by the injection of contrast medium into the common femoral vein, the vein is punctured at the level of the groin. After the polyethylene catheter has been passed into the vein, its position is controlled fluoroscopically during the injection of 10 cc of contrast medium. In conjunction with this, a test film is taken with the leg somewhat lowered. This film serves as a guide as to which veins are filled with contrast medium and where changes are to be found, thus affording an indication as to the main film series to be adopted. During the actual phlebography, the patient stands and leans backwards against the roentgen couch which is tilted at an angle of 60 degrees to the horizontal plane. Approximately 20 cc of 50 per cent Umbradil is injected during which procedure two films are exposed with the leg rotated into various positions, views which include the pelvis and thigh. Immediately afterwards, a further 20 cc are injected as rapidly as possible while a lateral and two or three a. p. radiograms are taken of the thigh and lower leg. The object is to attempt to determine — as did SYLWAN — to what extent the contrast medium passes in a retrograde direction when insuf-



a. b. c.

Fig. 3. Case 1. Retrograde phlebography through a catheter in the common femoral vein. a. Incompetent valves in the superficial femoral vein. — b and c. Dilated superficial veins of the lower leg filled from deep venous system.

ficiency of the femoral and popliteal veins is suspected. Finally, an additional 10 cc of contrast medium are injected and the film series is completed with radiograms of the lower leg and thigh as well as the pelvis (Figs. 3 and 4).

In the majority of cases, regardless of the investigation to be undertaken, phlebography is also carried out by the injection of contrast medium into a vein of the dorsum pedis. We use approximately the same technique as described by HØJENSGÅRD, GREITZ et al. Accordingly, the patient is examined standing with a rubber tourniquet placed around the leg at ankle height, and 50 to 60 cc of 50 per cent of contrast medium injected. Films are then taken so as to visualize the passage of the contrast medium up to the pelvis. If it be a question of exploration of the veins

a. b. c.

Fig. 4. Case 2. Retrograde phlebography through a catheter in the common femoral vein. a. The contrast medium passed the valves in the superficial femoral and popliteal veins. — b and c. Pathologic communicating veins at the level of adductor canal. The wide valveless v. profunda femoris is filled in a retrograde direction.

of the thigh and the pelvis, phlebography by the injection of contrast medium into a vein of the dorsum pedis is sometimes inadequate. In such cases, we have supplemented the examination with the injection of contrast medium into the popliteal vein.

The puncture technique described has been used throughout these examinations. The puncture is performed under local anaesthesia with the patient on the roentgen couch which is inclined to an angle of 45 degrees. The needle is introduced into the back of the leg, approximately 5 to 10 cm below the knee joint, somewhat lateral to the mid line. The needle is directed obliquely upwards and medially. The polyethylene catheter will thus lie with the tip pointed upwards in the vein. The examination is carried out with the table tilted at an angle of 60 degrees to the

a. b. c. d.

Fig. 5. Case 3. a. Slight filling of deep veins of thigh. — b. Through a catheter in the popliteal vein tortuous veins deep in the thigh are contrast filled. — c. The contrast medium passes up into the common femoral vein. — d. Taken 4 minutes after b. Note slow circulation rate of the contrast medium.

horizontal plane. From 40 to 50 cc of 50 per cent Umbradil is injected very slowly while films which include the pelvis and the entire leg in different projections are obtained; the same principles as in retrograde phlebography by the injection of contrast medium into the common femoral vein is followed. The examination has increased the opportunities of studying the circulatory conditions and pathologic-anatomic changes in the venous systems of the thigh and pelvis. These latter are especially important in post-thrombotic conditions of the femoral and external iliac veins with partial or total obstruction (Fig. 5).

Our experience with phlebography by contrast injection into the popliteal vein is as yet but small. The method may be used more extensively in the future and, perhaps, even on other indications than at present — for example, to examine the competence of the communi-

cating veins. Retrograde phlebography by the injection of contrast medium into the common femoral vein should be carried out in every case in which there is a suspicion of insufficiency in the veins of the thigh. Possibly, the indications for this examination will also become broader.

The following case reports are illustrative of the method:

Case 1. Male, aged 60; pulmonary emboli 18 months before phlebography; history of thrombophlebitis. Recurrent ulcers and increased swelling of the leg. Small varices on the skin.

Retrograde phlebography with injection of contrast medium through a catheter in the common femoral vein showed incompetent valves in the superficial femoral vein. At the level of the hiatus adductorius, some communicating veins were filled with contrast medium in a retrograde direction. Tortuous dilated superficial veins which were filled from the deep venous system were observed in the lower leg (Figs. 3b and 3c).

Case 2. Female, aged 39, with swelling and a sense of heaviness in the leg; no history of thrombosis; small varices observed on the back of the calf.

When retrograde phlebography by the injection of the contrast medium through a catheter introduced into the common femoral vein was performed, the catheter became twisted in the lumen of the vein. (The examination was carried out before 'leaders' were in use.) A wide, valveless vena profunda femoris was filled with contrast medium in a retrograde direction. Pathologic communicating veins were observed at the level of the adductor canal and the knee-joint (Figs. 4a, 4b and 4c).

Case 3. Female, aged 60; deep thrombosis in the leg twelve years previously; small varices of the leg; recurrent varicose ulcers, induration and eczematous changes in the lower leg.

Phlebography by the injection of contrast medium into a vein of the dorsum pedis, the medium passing up through the vena saphena magna. Slight filling of some of the deep veins in the distal part of the thigh was observed (Fig. 5a). By the injection of contrast medium through a catheter in the popliteal vein, a tortuous venous system taking on the function of the femoral veins was visualized deep in the thigh. Some of the contrast medium passed in a retrograde direction down the popliteal vein and the deep veins of the lower leg; from there, the vena saphena magna was filled through insufficiency of the communicating veins (Figs. 5b, 5c and 5d).

SUMMARY

A method for phlebography of the thigh is described. The contrast medium is injected through a polyethylene catheter introduced into the vein. This procedure offers several advantages among which are better protection for the operator against radiation and improved facilities for examining the patient in various positions. Illustrative cases are reported.

ZUSAMMENFASSUNG

Eine Methode für die Phlebographie des Oberschenkels wird beschrieben. Das Kontrastmittel wird durch einen Polyäthylenkatheter in die Vene injiciert. Diese Prozedur erbietet mehrere Vorteile, unter anderem besseren Strahlenschutz für den Operatör und verbesserte Möglichkeiten, den Patienten in verschiedenen Positionen zu untersuchen. Illustrative Fälle werden wiedergegeben.

RÉSUMÉ

Description d'une méthode de phlébographie de la cuisse. Le produit de contraste est injecté par un cathéter en polyéthylène introduit dans la veine. Ce procédé offre plusieurs avantages, entre autres une meilleure protection de l'opérateur contre les rayons et plus de facilité pour examiner le malade en différentes positions. Présentation de cas à titre d'exemples.

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FROM THE GYNECOLOGICAL CLINIC (DIRECTOR: PROFESSOR P. WETTERDAL)
OF KAROLINSKA INSTITUTET, STOCKHOLM, SWEDEN

STUDIES ON THE EFFECTS ON THE OVARIAN FOLLICLES IN THE MOUSE OF INTERNAL IRRADIATION WITH P^{32} WITH SPECIAL REFERENCE TO THE QUANTITATIVE EVALUATION

by

Erik Odeblad

In a previous work (ODEBLAD, 1952, II) attention was drawn to the occurrence of early changes in the mouse ovary, following subcutaneous injection of radioactive phosphate. It was shown that the follicular granulosa was the most radiosensitive tissue found in the ovary on histological examination, and that changes could be recorded as early as 48 hours after injection of 3 microcuries per gram of body weight (μC/g). In the present paper these early changes in the follicles have been subjected to a more extensive study with special regard to the possibility of obtaining a quantitative measure of the irradiation effect.

Experimental

A total of 163 virgin female albino mice of strain An 51 weighing about 20 g were used. They were subdivided into the following groups, also tabulated in table I.

I. 75 mice were used to study the relation between the time after the injection of radiophosphate and the damage. 15 animals (I K) were controls and were injected with 0.2 ml of carrier solution (1.0 mg Na_2HPO_4 per liter of distilled water). 15 animals (I A) were given 10 μC/g of P^{32}-labelled orthophosphate in 0.2 ml carrier solution 2 days before death, 15 others (I B) 4 days, 15 others (I C) 6 days and 15 other mice (I D) the same amount of P^{32} and carrier 10 days before death. After the animals were killed with ether, the ovaries were fixed in 6 per cent for-

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malin with 1/2 per cent trichloracetic acid; they were embedded in paraffin and cut in 4 μ thick sections which were mounted on methacrylate slides and autoradiographed on Gevaert Dentus Rapid film according to a technique described earlier (ODEBLAD, 1952, I). The sections were then stained with haemalum-eosin or according to MALLORY (1936).

II. The material accounted for in the preceding investigation (ODEBLAD, 1951, II) was used in part, so that 4 animals given radiophosphate 4 days before death were used at each of the following levels of dosage: 0.1 μC/g (II A), 0.3 μC/g (II B), 1.0 μC/g (II C), 3 μC/g (II D), 10 μC/g (II E) and 30 μC/g (II F), as well as a control group (II K) which was given carrier solution only. In that way the relation between the dose of P^{32} and the damage could be studied.

III. In order to obtain some information about the influence of the normal cyclic changes in the ovary, 60 untreated mice were divided after examination of the vaginal smears, into four groups with 15 animals in each group: di-oestric animals (III D), pro-oestric animals (III P), oestric animals (III O) and met-oestric animals (III M).

The histologic sections and the autoradiographs were compared and studied qualitatively. Special attention was drawn to the occurrence of so-named "blown-up" cells, earlier described by GRAHAM (1947) and GRAHAM et al. (1950) in the vaginal smears in cases of irradiated cervical carcinoma. The number of such cells per central ovarian section was counted, as well as the number of visible follicles per central ovarian section. The occurrence of mitoses in the granulosal tissue was also studied, and the apparent diameters of the follicles were measured with the aid of a linear micrometer scale in the eye-piece of the microscope.

Results

1. *General appearance of irradiated follicles.*

The general appearance of irradiated follicles has been described earlier (ODEBLAD, 1952, II) and is mainly characterized by reduction in the thickness of the granulosal layer (at first affecting the inner parts) as well as the occurrence of bizarre cellular and nuclear forms. The changes progressed with increasing time in the groups I A—I D and with increasing dosage in the groups II A—II F. Only rough estimation of the degree of irradiation effects can be made on the basis of this subjective examination.

2. *General appearance of autoradiographs.*

The large amounts of P^{32} present in the granulosa tissue seemed to be retained in the cellular débris after the cells had undergone degenerative changes due to irradiation. Autoradiographic density decreased some-

what with increasing irradiation, but these changes were too vague to be taken as a measure of irradiation effects.

3. *Occurrence of "blown-up" cells.*

The "blown-up" or "ballooned" cells (fig. 1) are characterized by their large cytoplasm which stains moderately and has a somewhat fine-vacuolized structure with a network of strings. The nucleus is somewhat

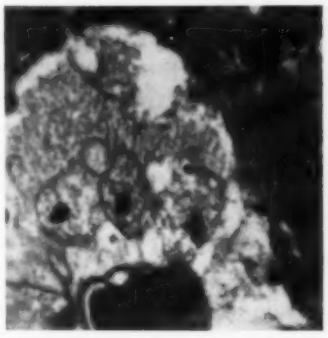

Fig. 1. Part of a growth follicle of a mouse in group I C. Three typical "blown-up" cells are visible above the egg cell (below). The nuclei are somewhat enlarged (about 5—7 μ) and the cytoplasm is considerably enlarged (15—25 μ). The normal measures are about 4 μ (diameter of nucleus) and 7—8 μ (diameter of the whole granulosal cell). Magnification × 445.

Table I

Group	Number of animals	Cyclic phases	Time after inj. of P^{32} days	Dosage of P^{32}, μC/g	Number of "blown-up" cells per section	Number of follicles per section	Mean follicular diameter, μ
I K	15	mixed	—	—	0	15.8 ± 0.5	145 ± 6
I A	15	mixed	2	10	0.8 ± 0.2	12.8 ± 0.6	134 ± 5
I B	15	mixed	4	10	2.6 ± 0.5	10.2 ± 0.7	94 ± 3
I C	15	mixed	6	10	1.0 ± 0.4	11.1 ± 0.7	75 ± 3
I D	15	mixed	10	10	0.2 ± 0.1	11.5 ± 0.7	70 ± 4
II K	4	mixed	—	—	0	15.1 ± 0.6	156 ± 10
II A	4	mixed	4	0.1	0	13.4 ± 0.7	150 ± 10
II B	4	mixed	4	0.3	0	15.7 ± 0.7	154 ± 11
II C	4	mixed	4	1.0	0	11.2 ± 0.6	145 ± 9
II D	4	mixed	4	3	0	10.8 ± 0.6	133 ± 9
II E	4	mixed	4	10	2.0 ± 0.9	12.0 ± 0.7	98 ± 7
II F	4	mixed	4	30	4.6 ± 1.4	9.0 ± 0.6	89 ± 6
III D	15	di-oestrus	—	—	0	8.5 ± 0.7	150 ± 8
III P	15	pro-oestrus	—	—	0	11.8 ± 0.6	161 ± 7
III O	15	oestrus	—	—	0	11.5 ± 0.6	162 ± 7
III M	15	met-oestrus	—	—	0	13.8 ± 0.7	155 ± 6

The ±-values denote the mean error.

enlarged and stains densely and is situated either in the center or near the cellular membrane. The "blown-up" cells are easily recognized. They were not seen in the ovaries of unirradiated mice. In met-oestric mice or those with follicular atresia, cells could be seen, possessing certain similarity with "blown-up" cells but easily distinguished by their type of vacuolization, which was similar to that of fat cells in paraffin sections.

The "blown-up" cells were considered as signifying irradiation damage during the prevailing experimental conditions. They could be found only in growth and Graafian follicles. Their maximum frequency 4 days after injection of P^{32} (table I) indicates that they represent a transitional stage associated with rapid degeneration of granulosal cells. As indicated in table I there was also a relation between the dose and the frequency of "blown-up" cells. The small number of such cells per section makes the statistical error great in quantitative evaluation.

4. *Occurrence of other cytologic types.*

The nuclear fragments and pyknotic nuclei in irradiated granulosal tissue seemed to grow more numerous with increasing dosage and with increasing time after the injection of radiophosphate. However, such nuclear types are common in normal animals, especially in met-oestrus, and they can in no way be taken as an index of irradiation effects in quantitative work.

Cytoplasmic vacuolization in vaginal smears was considered as highly specific for irradiation damage by GRAHAM et al. (1950). In the granulosal tissue it seems somewhat more specific for radiation effects than nuclear fragmentation and pyknosis, but it is also seen in unirradiated animals in met-oestrus and in atretic follicles in other cyclic phases, as mentioned above.

5. *Inhibition of mitosis.*

Mitotic divisions are normally present in the granulosal cells, especially in the growth follicles. They seemed completely inhibited in the groups I A—I D and in II E and F. Because of the heterogeneous spatial distribution of mitoses within the follicles, most common near the egg cell and near the antrum (BULLOUGH, 1942, verified by the author), counting of the mitotic index was considered difficult to perform in a comparable way from case to case, and could be performed only on growth follicles with the egg cell sectioned centrally. The small size of the granulosal cells and the possible presence of abnormal mitoses contributed to make the counting of mitoses difficult and unreliable as a measure of radiation injury of the granulosal tissue.

6. *Number of follicles per histologic section.*

As indicated in table I the mean number of follicles per centrally situated histologic section appeared to decrease with increasing dosage of P^{32} and increasing time after injection. However, the analysis of group III showed that there is a very great cyclic variation of this figure, which seems to be due mainly to the excessive development of the corpora lutea; these occupy the major part of the sections during di-oestrus, and are relatively small during met-oestrus. The number of follicles per section may therefore not be considered as a reliable measure of the effects of irradiation.

7. *The size of the follicles.*

The mean apparent diameter of the follicles showed continuous decrease with increasing dosage of radiophosphorus and with increasing time after the injection of this isotope, as shown in table I. The analysis of group III indicated that a cyclic variation lies within the limits of accuracy of the measurements.

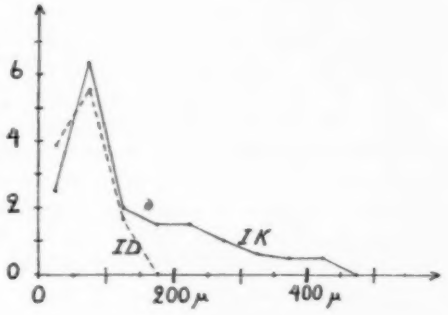

Diagram 1. Size-distribution curves of follicles for normal mice (I K) and irradiated mice (I D). Ordinate: mean number of follicles per section. Abscissa: apparent diameter of follicles. The absence of large follicles in group I D is clearly indicated.

Size-distribution curves showed the presence of a nearly logarithmic-normal distribution, which is also theoretically justified (CRAMÉR, 1946) for biologic objects such as the follicles, the growth of which is regulated by external stimuli. This type of size-distribution curve permitted the calculation of the mean error. There is some interference by the arc-sine function, governing the apparent distribution of diameters in the corpuscular problem, as pointed out by WICKSELL (1926). This interference mainly causes a slight widening of the margins of error, due to its smoothing effect of the distribution curve for the real follicular diameters.

The analysis of the size-distribution curves showed that it is mainly the larger follicles (exceeding 150 μ in diameter) that are reduced in frequency in irradiation, while the frequency of the smaller follicles

somewhat increases. These findings indicate arrest of follicular growth due to irradiation.

On the whole the measurement of the apparent follicular sizes seems to permit careful quantitative studies on the effects of irradiation.

Discussion

In quantitative evaluation of irradiation effects on the ovary it is of great importance that centrally situated sections (through the hilus) are used. In addition, the histologic procedures, including shrinkage during the fixing, and expansion during the floating on water of the paraffin sections, are not allowed to vary too much from case to case. The dosage of the radioisotope must be carefully controlled by determinations and comparison with a uranium (or other suitable) radioactive standard preparation with known impulse rate. All these requirements have been fulfilled as far as possible in the present investigation.

The general appearance of the follicles in the histologic sections and on the autoradiographs, the occurrence of nuclear fragmentation and pyknosis and of cytoplasmic vacuolization, the inhibition of mitoses and the changes in the number of follicles per section show all certain characteristic features; these, however, do not permit quantitative analysis due to the reasons given above.

The "blown-up" cells seem highly significant of irradiation damage under the prevailing experimental conditions, and are therefore of great importance. The counting of these cells is subject to considerable statistical error unless the material examined be large. A reliable index of irradiation effects was found in the mean apparent follicula diameter. The measurements are time-requiring but are simple to perform and show reproducible results (compare *e. g.* group I B and II E).

The value of obtaining a method of quantitative estimation of irradiation effects for radiation and isotope research on the ovary is evident. It may be possible to compare quantitatively the effects of various isotopes, *e. g.* (a) P^{32} with P^{33}, or (b) P^{32} with S^{35}. It will also be possible to compare the effects caused by different types of radiations, *e. g.* (c) internal beta rays with roentgen rays and neutrons, and to (d) investigate the protective action of sulfhydryls on irradiation damage. All these problems (a)—(d) as they apply to the ovary and demand quantitative radiobiologic methods, are now under investigation by the author.

SUMMARY

The ovaries of mice in various cyclic phases, of mice injected with P^{32} at different points of time before death and of mice given different amounts of P^{32} were studied as regards the possibility of obtaining quantitative methods of studying the irradiation

effects on the follicles. The general appearance of the follicles in histological sections, the autoradiographs, the occurrence of nuclear fragmentation, pyknosis and cytoplasmic vacuolization as well as the inhibition of mitoses cannot for various reasons be used for quantitative evaluation. The counting of "blown-up" ("ballooned") cells and the measurement of apparent follicular diameters seem to permit quantitative studies on the early irradiation effects on the ovarian follicles.

ZUSAMMENFASSUNG

Die Ovarien von Mäusen in verschiedenen Zyklusphasen wurden nach Injektion von P^{32} in variierender Dosis und an verschiedenen Zeitpunkten vor dem Tode in der Absicht untersucht, quantitative Methoden zur Messung des Strahleneffektes zu erreichen. Das allgemeine Aussehen der Follikel im histologischen Schnitt, das autoradiographische Bild, das Vorkommen von Kernfragmentierung, Pyknosis und Zytoplasmavakuolisierung sowie die Hemmung der Mitosen konnten aus verschiedenen Gründen nicht für quantitative Studien verwendet werden. Durch Zählen der ballonierten Zellen ("blown-up cells") und durch Messung des Follikeldiameters scheint es möglich, frühzeitige Strahlenveränderungen in den Follikeln quantitativ untersuchen zu können.

RÉSUMÉ

Pour établir des méthodes quantitatives d'analyse des effets biologiques des radiations, on a étudié les ovaires de souris adultes à différentes phases sexuelles, après injection de P^{32} à des doses différentes et à différentes époques avant leur mort.

L'aspect histologique général des follicules, les auto-radiographies, la fragmentation et la pycnose nucléaire, la vacuolisation du cytoplasme et l'inhibition des mitoses n'ont pu, pour diverses raisons, servir à cette analyse quantitative.

La numération des cellules ballonnées ("blown-up cells") et la mesure du diamètre des follicules ont pu être utilisées pour l'étude quantitative des radiolésions des follicules de l'ovaire.

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FROM THE DEPARTMENT OF RADIOLOGY AND THE RADIUM CENTRE (DIRECTOR: PAUL JACOBY), THE COUNTY AND CITY HOSPITAL, ODENSE, DENMARK

OSTEOARTHROPATHY IN SYRINGOMYELIA

Analysis of Seven Cases

by

J. Skall-Jensen

Osteoarthrography in patients with syringomyelia has in the course of time been given some attention by the medical staff of the Department of Radiology and the Radium Centre in Odense, and the recent publication by HAUGE (7) of a study on the subject aroused renewed interest in this disease.

HAUGE emphasized the importance of vascular reactions and mentioned several authors who have expressed similar views (8, 12). I feel that it may be of interest to publish our observations and discuss them in the light of these opinions.

Case Material

Our institution consists of the Radium Centre, the Department of Radiology (which is subdivided into two services, one for therapy and the other for diagnostic radiology) and a clinic for light therapy. Our case records comprise patients who have been admitted to the Radium Centre or been referred to the out-patient clinic for treatment, either by general practitioners or from other departments of the hospital. Accordingly, the length of time during which the individual patient has been followed varies within wide limits.

A feature common to all the patients included in this report is the slow development of dissociated anesthesia and muscular atrophy, both arising in the distal parts of the upper extremities, whereas a number of other signs varied from patient to patient. Some cases in which the diagnosis of syringomyelia was questionable have been excluded.

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During the period from 1929 to 1952 a total of 22 patients, 13 men and 9 women, were treated for syringomyelia. Their ages ranged from 16 to 72 years. According to the patients' statements, the age at the onset of the initial symptom varied from 13 to 54 years.

Seven of these patients had osteoarthropathy. All of them complained of some symptom or other in the upper extremities; symptoms in the lower extremities were present in two cases, and one patient had bulbar symptoms. In one patient both elbow joints were involved, while the osteoarthropathy was monarticular in the remaining six, involvement of one elbow being found in one case, of the right shoulder in one, and of the left shoulder in four cases.

Clinical Picture of the Osteoarthropathy

In two cases we observed the acute phase of the development of the osteoarthropathy and in four cases details of the past history of the acute phase were available. In one patient, aged 72 at the time of treatment, the arthropathy was stated to have been present since childhood. In six cases in which information as to the onset of the joint affection was available, it appeared that swelling of the joint was the initial symptom. In most cases the swelling was very pronounced; it resulted in limitation of movement and persisted for several months. Three patients complained of pain, whereas in three others the condition was absolutely painless. A history of trauma could not be elicited in any case. During the development of the osteoarthropathy a biopsy was performed in two instances, but the histologic examination of the specimens removed was uncontributory. The temperature was not recorded in any of the patients during the acute phase, but the general health remained unimpaired. Discoloration of the skin was not present.

Roentgenographic Appearance

The evaluation of the course of the osteoarthropathy was based on the observations published by BRAILSFORD (2). He demonstrated that the various types of osteoarthropathy which were thought to be in existence before that time represented only different phases of the lesion, and that these had a characteristic course of development. In the early part of the disease soft-part swelling but no roentgenographically demonstrable osseous changes were present. Gradually, extensive destructions in the joint and calcifications in the soft parts developed. Later, a slowly progressing bone atrophy and incipient absorption of the calcifications were seen, accompanied by formation of osteophytes. Finally, the osteophytes also were partially absorbed.

In two of the patients of the series no roentgenologic changes could be demonstrated at the onset of the swelling or 6 weeks later. In the second of these (case 2) bone destruction was first observed after the lapse of 3 months; in two others incipient destruction appeared after 3 weeks (case 1) and 5 months respectively. Extensive destruction developed within periods ranging from 5 to 12 months in five patients. Commencing absorption of the calcifications in the soft parts in two cases appeared 2 and 3 years after the onset of the swelling. Formation of osteophytes was observed in two cases: in one 8 years, and in the other more than 10 years, following the acute phase. One of the patients has been followed roentgenographically for 8 years and three others for 9 months, 2 years and 3 years, respectively.

Discussion

The times given do not signify the boundaries between the various phases in the development of the osteoarthropathy, since the roentgenograms were taken at incidental times during the progress of the disease. All intermediate gradations between the various phases may be encountered. In some instances, the joint changes may develop within a very short space of time (11), while in others the process may extend over a considerable period. The greatest rapidity of development of joint changes observed in this series occurred in case 1, in which incipient bone destruction and extensive calcifications in the soft parts were evident three weeks after the onset of swelling. In another patient (case 2) bone destruction and calcifications had not developed six weeks after the onset of swelling of the shoulder joint. These findings were noticed for the first time after the lapse of three months. These two cases are briefly reported below.

Case 1. — A woman, aged 52, admitted in 1942. At the age of 30, she had suffered from inability to extend completely all the finger joints, but according to her own statement, there had been no pain and sensibility had been normal. On the admission in 1942 she complained of a feeling of progressive fatigue in the left arm and of muscular weakness and restricted range of movement of the left shoulder joint. No history of trauma. Three weeks prior to admission painless but marked swelling of the left shoulder had developed. Physical examination revealed a large swelling of the left shoulder, notably of the anterior aspect. The appearance of the skin was normal. Pain and temperature sensations were lost over the entire left extremity. A diagnostic biopsy of the joint was performed on Dec. 11, 1942, but no pathologic findings were revealed. A roentgenogram (fig. 1) taken on Dec. 4, 1942, showed a marked swelling of the soft tissues around the shoulder joint, vague calcifications in the soft parts and much destruction of the upper portion of the head of the humerus, so that this had become detached and was luxated antero-inferiorly. Three years later the head of the humerus had completely disappeared (fig. 2), and the calcium deposits were being absorbed. The patient died of leukemia in 1947. No signs of this disease had been present on first admission in 1942.

Case 2. — A man, aged 32, entered our department in January 1952. He had previously been admitted to the Neurological Department in 1951. Two or three months before the first admission swelling around the left shoulder joint developed, accompanied by crepitation on movements of the joint. There had been no preceding trauma. Physical examination revealed a considerable swelling of the left shoulder and loss of pain and temperature sensations over the entire left upper extremity; at the time of writing, 14 months later, the swelling still persists. A roentgenogram taken 6 weeks after the onset of the swelling showed nothing abnormal. Three months after the onset, the first signs of destruction (abrasion of the glenoid cavity) appeared, and at the same time calcifications in the soft parts were observed. The destruction showed gradual progression; 12 months after the first roentgenogram the entire glenoid cavity had been eroded, and there was a large area of destruction in the head of the humerus. Extensive soft-part calcifications were still present (fig. 3).

During the course of time mechanical wear has been stressed as the essential cause of the articular destructions. It was believed that the painless joint was destroyed by wear which occurred to an abnormal extent owing to the loss of sensibility. However, there are two factors which are against this being the most probable explanation, viz. (1) that we, in agreement with other writers, have found that the affected joints are painful in about 50 per cent of cases of syringomyelia, and (2) that the destruction may develop very rapidly without any preceding trauma (cf. case 1). It would be expected that if brought about by mechanical wear, the destruction would progress very slowly. In this connection it may be pointed out that biopsy did not play any traumatic rôle, since a typical osteoarthropathy had developed before it was performed.

Originally, CHARCOT (3) advanced the theory that owing to the pathologic processes in the spinal cord an affection would develop in some hypothetical trophic nerve fibres in the joint. This theory has now been abandoned, since it has never been possible to demonstrate the presence of such trophic nerve fibres.

The most plausible explanation is, perhaps, that due to the progressive processes in the spinal cord, vascular changes occur in and around the joint, ultimately resulting in the development of osteoarthropathy. The pronounced swelling seems to point to a question of vascular reaction. The vascular changes may conceivably represent a transitory condition, if it be assumed that the balance of the sympathetic innervation is disturbed locally for a certain time; this may very well be the case owing to the progressive processes in the spinal cord. As already mentioned, HAUGE (7) and other writers (1, 4, 6) have emphasized the possible existence of a causal relationship between arthropathy and an affection in the sympathetic nervous system.

Osteoarthropathy may be encountered in a number of different diseases. Recently, KNUTSSON (9) published a report on a case of diabetic arthropathy.

Fig. 1. Case 1. Three weeks after the onset of swelling of the shoulder. Destruction of the head of the humerus, periosteal reaction, and calcifications in the soft parts.

Fig. 2. The same case, three years later. Complete disappearance of the head of the humerus and incipient absorption of the calcifications.

Fig. 3. Case 2. 13 $^1/_2$ months after the onset of the disease. Complete disappearance of the glenoid cavity and extensive destruction of the head of the humerus.

The most frequent cause of osteoarthropathy is tabes dorsalis. In tabes it is possible that the processes situated in the regions around the nerve roots may result in a disturbance of the sympathetic innervation. In an effort to elucidate the conditions in tabes by animal experiments, ELOESSER (5) cut the posterior nerve roots in the hind legs of 69 cats. In some cases bilateral section was employed, in others only unilateral section. Arthropathy developed in some of the animals, and a large number of fractures occurred. According to his explanation, the fractures were due to ataxia and loss of sensibility; the ataxia caused abnormal muscular traction on the bones resulting in fractures. He mentioned the lack of protection against trauma, due to the loss of sensibility, as an essential cause of the destruction of bones and joints.

A comparison of these experimental results with the conditions observed in tabetic patients shows that they correspond to complete loss of sensibility, but obviously the special arthropathy associated with vascular reaction, due to an affection of the sympathetic nervous system, could not be expected to develop in these experiments with simple section of the posterior nerve roots.

From a paper published by FLEMMING MØLLER (10) it appears that swelling of the joint is far from always being the initial symptom in tabetic arthropathy, and that two types may be encountered, one in which drastic bone destruction occurs very rapidly and another more chronic variety in which the destruction is often less extensive. These observations may suggest that the cause of tabetic arthropathy is not invariably the same in all cases.

FLEMMING MØLLER expressed the opinion that the primary cause of the development of tabetic arthropathy is an increased fragility of the bones and joint cartilages, which may be attributed to the lesions of the spinal cord.

ALAJOUANINE and MAURIC (1) showed that sympathetic disturbances may be of importance. They subjected a patient with tabetic arthropathy to perivascular sympathectomy, with the result that the local edema and discoloration of the skin as well as the elevation of temperature subsided within a couple of days. In their opinion, the result proved the presence of preoperative sympathetic disturbances.

The studies cited and a review of our own case records show that swelling of the joint is often the initial symptom of arthropathy in tabes and invariably so in syringomyelia. This fact correlated with the aforementioned effect of sympathectomy seems to suggest that vascular changes play an essential rôle in the pathogenesis of osteoarthropathy.

SUMMARY

Seven of a total of 22 patients with syringomyelia observed during the years 1929—1952 had osteoarthropathy. This material seems to show that osteoarthropathy is a joint affection in which vascular changes play a very considerable rôle. The vascular reactions are presumably due to disturbances in the sympathetic system caused by the progressive pathologic processes in the spinal cord.

ZUSAMMENFASSUNG

Bei 7 von insgesamt 22 Patienten mit Syringomyelie, die innerhalb der Jahre 1929—1952 beobachtet wurden, lag eine Osteoarthropathie vor. Das Material scheint zu zeigen, dass die Osteoarthropathie eine Gelenkerkrankung ist, bei der Gefässveränderungen eine beträchtliche Rolle spielen. Die Gefässreaktionen sind wahrscheinlich von Störungen im sympatischen Nervensystem abhängig, die durch progressive pathologische Prozesse im Rückenmark bedingt sind.

RÉSUMÉ

Sur un total de 22 malades atteints de syringomyélie observés de 1929 à 1952, sept présentaient des ostéo-arthropathies. Ce matérial semble montrer que l'ostéo-arthropathie est une affection où les modifications vasculaires jouent un rôle très considérable. Les réactions vasculaires sont vraisemblablement dues à des troubles du système sympathique causés par les lésions progressives de la moelle.

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FROM THE UNIVERSITY EAR, NOSE AND THROAT CLINIC (DIRECTOR: PROFESSOR DR. EELCO HUIZINGA), AND THE RADIOLOGICAL INSTITUTE (DIRECTOR: PROFESSOR DR. S. KEYSER), GRONINGEN, THE NETHERLANDS

COLLAPSE OF THE LUNG AND BRONCHOGRAPHY

by

Eelco Huizinga and *C. G. Sypkens Smit*

It is regrettable that the word atelectasis is used both in connection with resorption and compression in diseases of the lungs. It is best to use the word atelectasis only in cases of resorption, as POLICARD (10) proposed, and to use the word collapse when referring to compression; there are marked differences in: 1. the aetiology, 2. clinical signs, and 3. microscopy of these two conditions.

Ad 1. If we consider the causes of the disappearance of air from the lungs, the following four possibilities exist:

a. The air behind the obstruction is absorbed.

b. The air is forced out of the lung by an expanding process.

c. The air is replaced by a transudate, exudate or secretion.

d. In cases of blocking the air is replaced as a result of ciliary action in the bronchi. (HILDING, 5.)

a. is resorption atelectasis and *b.* is called compression atelectasis. It is apparent from the literature that many have difficulty in grasping that the air, containing 80 % nitrogen, can be absorbed so quickly. This has given rise to various far-fetched theories, *i. e.*, that a ball-valve mechanism develops so that only expiration is possible and the lung is pumped empty. This explanation, given by GAIRDNER (3) as early as 1850, recurs now and again. But when one has observed in bronchograms the narrowing of the bronchi at the precise moment of expiration, one cannot possibly accept this theory. The opposite, *i. e.*, an obstructive emphysema due to bronchial stenosis, is more comprehensible.

In connection with absorption atelectasis it is often overlooked that the diffusion of every gas depends on its own partial pressure and is

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completely independent of the presence of other gases. When oxygen is absorbed the space becomes smaller (leading to collapse of the walls or transudation). The tension of the remaining nitrogen is higher than the tension in the blood and is thus also absorbed. In this manner all the air behind the obstruction disappears.

Ad 2. Whereas process *b.* is usually rather harmless so that after many years complete recovery of the lung, at least anatomically, is possible, process *a.* is nearly always attended with infection; this may involve dangerous complications and even more frequently irreversible changes with bronchiectasis of the lung.

Ad 3. Besides the infection there are still other anatomic differences between *a.* and *b.* The compressed lung in *b.* is ischemic, whereas the lung in *a.* is hyperemic; this is because venous blood flows in as soon as absorption of the air commences. The transudate into the alveoli which partially, or sometimes even completely, replaces the absorbed air, is probably a result of dilatation of the capillaries. This "atelektatische Anschoppung" has also been found by CORYLLOS and BIRNBAUM (1) and by HERRMANN and SCHOPPER (4) in experiments in animals. The transudate easily turns into an exudate as a result of infection. The secretion distal to the stenosis cannot be coughed up or removed by ciliary action. In this way the "drowned lung" comes into being. This belongs to *c.*, but in that case it is not called atelectasis. It is obvious however, and this makes it complicated, that the differentiation between *a.* and *c.* is difficult. Nowadays the term "obstruction pneumonitis" is often used, though it seems to be hard to distinguish these cases from infected atelectasis.

Very little is written on lung collapse in the bronchologic literature. Yet the condition is often observed clinically and frequently gives rise to mistakes. This is especially the case when we are dealing with what we have called "a temporary high position of the diaphragm". In a previous communication with MEYLER (8) attention was drawn to this syndrome, usually seen on the right, occasionally on the left and exceptionally on both sides. In all our cases there was an inflammatory process under or above the diaphragm, often from the gallbladder (without or after operation) or a pleural effusion. The possibility of diaphragmatitis temporarily decreasing the tonus and the mobility of the diaphragm, arose. We then considered that we were dealing with a new syndrome. The subject was worked out later in a thesis by C. G. SYPKENS SMIT (12). It then appeared that the syndrome had already been described by HITZENBERGER (6) and by NORRIS and LANDIS (9) among others. FLEISCHNER (2) also mentioned a high position of the diaphragm as one of the causes of the appearance of "compression atelectasis".

But this syndrome had never before been described so elaborately and it was unknown that it occurred so often; after attention had once been drawn to it another 24 cases were added within a very short time to those already described. All the patients had inflammatory processes above or below the diaphragm: pneumonia, pleuritis, pulmonary embolus, cholecystitis (commonly), pancreatitis (in which case the left side of the diaphragm was raised). The prognosis was nearly always favourable and complete recovery usually set in after a few weeks. It is generally clinically impossible to establish the cause of the raised diaphragm with certainty. Autopsy was performed on a patient with pleuritis, in whom a high position of the diaphragm was diagnosed during life; microscopic investigation of the diaphragm was thus possible (VAN RIJSSEL). An obvious diaphragmatitis was found, the probable cause of the high position. The diaphragm was examined microscopically in 20 further autopsies (VAN RIJSSEL). In two patients who had died of peritonitis and pleuritis respectively, obvious diaphragmatitis was established; in 4 patients with pneumonia the pleura diaphragmatica was inflamed on the same side; in 3 patients pleuritis did not appear during life. It is thus obvious that inflammation of the diaphragm may readily occur; this is easily comprehensible in view of the many connections via the lymphatic and blood vessels.

In practice it is important to be familiar with this syndrome for it often gives rise to mistakes. The clinical signs will consist of a sharply defined dullness on percussion with decreased breath sounds in the lower part of the thorax. Pleuritis will obviously be considered. If insufficient attention is paid to the diaphragm on roentgen examination superfluous needling may be carried out. Another erroneous diagnosis, often made because the high position often occurs after abdominal operations, is post-operative atelectasis. In our first few cases bronchostenosis with resorption atelectasis was considered. Bronchoscopy and bronchography was consequently carried out on 7 patients. These examinations showed that there was no sign of bronchostenosis but compression atelectasis as a result of the high position of the diaphragm, was present.

It has been established that the raised dome has a very defined effect on the lung, the basal part only of which is compressed. This gives rise to a characteristic bronchographic picture, the alveolar filling being absent in this portion of the lung. The appearances of the compressed larger bronchi with "naked filling" remind one strongly of bronchiectasis. There is, however, no question of this, for after recovery and reventilation of the lower lobe, normal bronchi re-appear.

The same change also occurs when the high position of the diaphragm is permanent and not temporary. The following is an illustrative case.

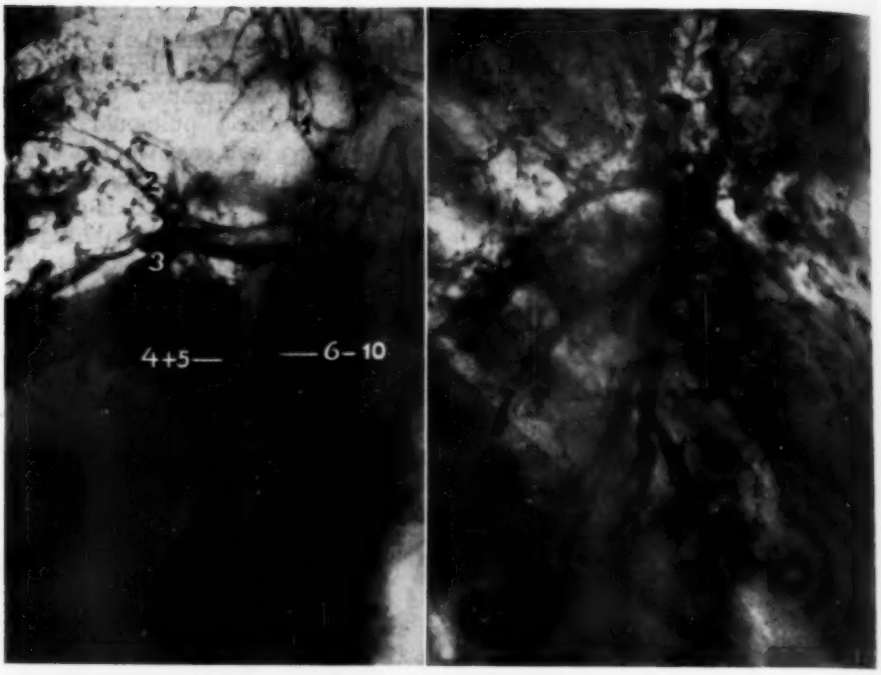

Fig. 1. Fig. 2.

Fig. 1. Case 1. P. A. view. Right side.
1 = apical bronchus of the upper lobe; 2 = posterior branch of the upper lobe bronchus; 3 = anterior branch of the upper lobe bronchus; 4—5 = bronchi of the middle lobe; 6—10 = bronchi of the lower lobe.
The bronchi of the middle and lower lobes displaced towards the midline. "Naked filling" in the lower lobe.

Fig. 2. Lateral view of the same case. A comparison with Fig. 1 shows that the middle and lower lobes are compressed into a narrow disc in the sagittal plane.

Case 1. (Fig. 1 and 2.) A woman aged 49 with kyphoscoliosis; pain in the right chest three months previously, diagnosed as pleurisy; no improvement with rest. On examination, the right dome of the diaphragm was much higher than the left. Bronchography was performed.

The apical bronchus of the upper lobe emerges separately from the main bronchus (Fig. 1). The upper lobe bronchus with the posterior and the anterior lateral branch arise very low down; the main bronchus is, therefore, long. The dome of the right diaphragm is high, the region of the middle and lower lobes is obscured by a shadow and the bronchi of the middle and lower lobes are displaced towards the mid-line. The middle and lower lobes are compressed into a narrow disc in the sagittal plane. This is clearly shown in the lateral view (Fig. 2); the various lateral branches are clearly

visible in this projection. The circumscribed effect on the lung is of interest; the upper lobe is completely normal, a "naked filling" being seen in the lower lobe.

This bronchographic picture is, of course, not typical of a high position of the diaphragm; it belongs to collapse and may arise from a different cause. In practice one should be familiar with these appearances. These cases are also of importance from a theoretical point of view.

It has long been an open question, important from both the physiologic and pathologic standpoint, as to whether the elasticity of the lung is such that a localised force affects a limited part or the whole of the lung evenly. Closely connected with this is the question of the equal or unequal ventilation of the lung. Most physiologists take the point of view of the even effect; an exception is KEITH (7), who for many years has been in favour of the theory of the limited effect. RAUWERDA (11) confirmed KEITH's views by his experiments in gas analysis.

The pathologico-anatomists generally hold quite a different view. In nearly all handbooks examples of limited effects are given, especially in patients with kyphoscoliosis and pleural exudates. TENDELOO (13) who made important observations on this subject, stated "a force locally extending or compressing the lung in a demarcated area causes changes in the dimensions of the lung which are only local and which scarcely spread to the surroundings". A few examples of bronchograms obtained in cases of various defined processes in the thorax, which gave rise to collapse of a limited part of the lung, are given below.

Case 2. (Fig. 3.) A man aged 58, with old left-sided pleurisy, markedly calcified. Bronchiectasis was suspected and bronchography performed. It is striking that the markedly thickened pleura at the base has caused considerable compression of the lower lobe. The lower lobe bronchi lay very closely together. The upper lobe was normal, with the exception of the lingula which was compressed. The appearances of the bronchi could easily be mistaken for bronchiectasis. There was again a "naked filling" especially of the anterobasal and posterobasal bronchi as a result of the collapse of the lower lobe.

Another abnormality often occurs in such a case. The medial aspect of the main bronchus was bounded by a large number of small diverticula producing a fringe-like appearance. On bronchoscopy a number of small openings to the diverticula which were lined with normal mucous membrane, were noted. The picture is characteristic and is probably caused by old retention cysts of the glands of the mucosa which have again burst into the lumen, the openings always being visible on bronchoscopy. It is only encountered in association with chronic cough, and is not mentioned in the literature.

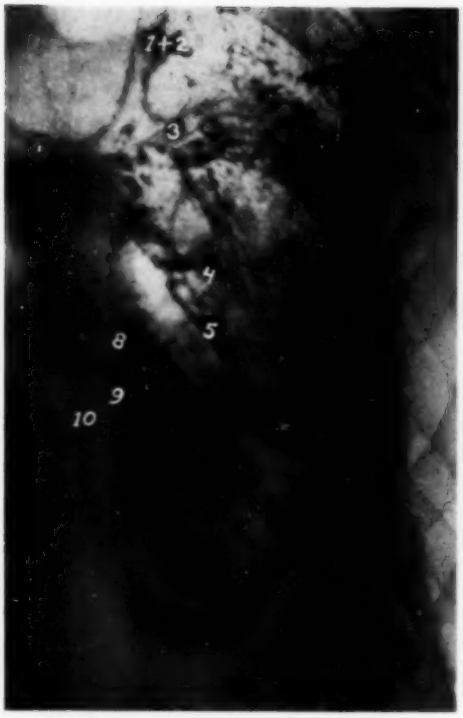

Fig. 3. Case 2. P. A. view. Left side. Thickened, partly calcified pleura causing compression of the lower lobe. "Naked filling" especially of the anterobasal (8) and posterobasal bronchi (10).

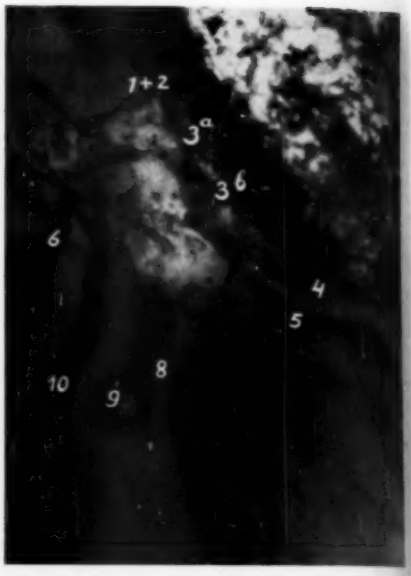

Fig. 4. Case 3. P. A. view. Left side. The lingula branches (4 and 5) have an irregular twisting course and are displaced upwards—forwards. "Naked filling" of the bronchi of the lower lobe, especially of the basal branches (8, 9, 10).

Case 3: A man aged 20 with a hemorrhagic pleural effusion. On roentgen examination a dense shadow was seen in the periphery of the left base. Clinical diagnosis: probably bronchostenosis. Bronchoscopic examination: negative. Bronchography: normal filling of the left lung. The lateral branches of the ascending branch of the upper lobe bronchus show a normal appearance. The lingula branches are markedly displaced upwards and forwards (Fig. 4). The irregular twisting course of the branches of the lingula, especially of the lower branch is remarkable. The lung tissue of the lingula is compressed, the pattern of the acini having practically disappeared. The lower lobe bronchi are all present and well filled. There is also obvious collapse. But here and there, especially in the region of the anterobasal bronchus some acini are visible. On the whole, however, there is again a "naked filling" of the bronchi of the lower lobe, especially of the basal branches. The bronchi lie close together.

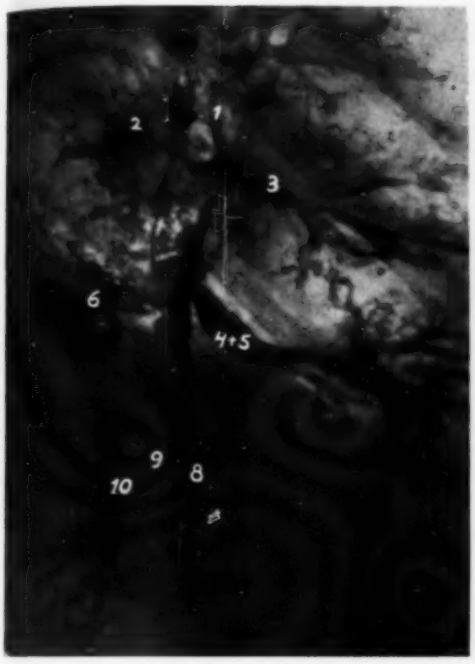

Fig. 5. Case 4. Lateral view. Right-sided pleurisy. "Naked filling" of the basal bronchi of the lower lobe (8, 9, 10). Slight compression of the apical segment of the same lobe (6), more marked of the middle lobe (4, 5).

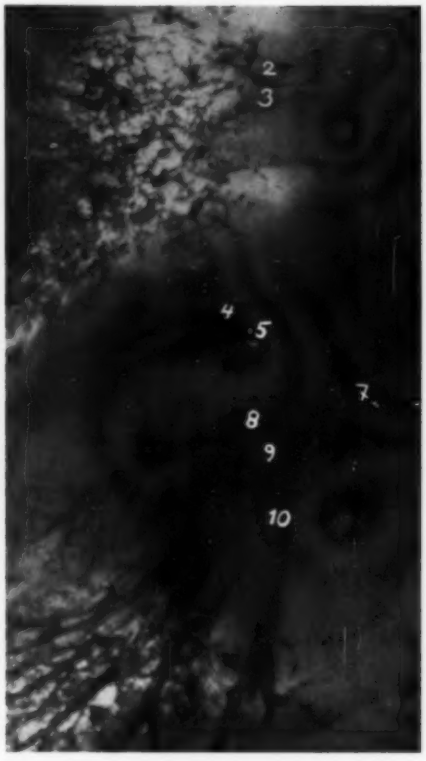

Fig. 6. Case 5. Mediastinal tumor causing "naked filling" of the bronchi of the middle lobe (4 and 5) and the bronchus cardiacus (7).

Case 4: A man aged 38, five years previously operated on for acute appendicitis; two years previously an abscess of the liver; several operations for liver abscesses. Obviously, perforation had occurred into the pleura; there were fistulae in the front and back of the thorax. To make the complicated relations clearer bronchography was performed. The lateral bronchogram (Fig. 5) shows another typical example of a defined collapse as a result of a markedly thickened pleura and effusion. The effect on the lung is very much localised, especially of the basal bronchi of the lower lobe. These are strongly compressed. They show a "naked filling", the untidy appearances being again suggestive of bronchiectasis. There is only slight compression of the apical segment of the lower lobe but more marked compression of the lower part of the middle lobe which has also been displaced upwards.

Fig. 7. Case 6. No localized compression of the basal part of the lung in a case of pneumoperitoneum.

These cases of limited pulmonary compression may give rise to peculiar bronchographic appearances, at times difficult to interpret.

Case 5: A man aged 39; large rounded shadow in the right chest on mass roentgen examination caused by a mediastinal tumour; dullness on the right side.

In this case a naked filling of the bronchi of the middle lobe and the cardiac bronchus is seen (Fig. 6).

The acini are thus compressed on collapse as apparently are the smaller bronchi. The same is also seen in resorption atelectasis as has been shown by FLEISCHNER. It would be interesting to find out which of the smaller bronchi are compressed; a few are sometimes penetrable as the design of the acini in some areas remains visible. But the situation is generally such that only the larger branches are open and are obscured by the compressed acini plus the bronchioli and smaller bronchi. This presents on the bronchogram the appearance termed in bronchographic slang: "a naked filling of the bronchi".

It is remarkable that the lung always behaves according to TENDELOO's law, the effect of the compression being always very much limited. A great number of examples might be added. We were very much indebted to our colleague DIJKSTRA for showing us 25 cases in whom phrenico-exeresis together with pneumoperitoneum had been applied as collapse therapy for tuberculosis. The same result as has been described above appeared in the majority of these cases: a defined compression of the basal parts of the lower and middle lobes had occurred. The next case presents quite a different picture: a diffuse influence on the whole lung. This can hardly be explained in any other way than by assuming that there are individual differences depending on the amount of elastic tissue present in the lung.

Case 6: A woman aged 24; in the apical segment of the right lower lobe a moderately extensive, tuberculous process with a cavity about the size of a chestnut. After a month successful alcoholisation of the nervus phrenicus on the right side a pneumoperitoneum was performed. This caused considerable raising of the diaphragm, the right side being 7—8 cm higher than the left (Fig. 7). The right lung has become much smaller in this case, but in contrast with the usual picture, localised compression of the basal part of the lung did not occur. The bronchi in the lower and middle lobes had a normal appearance, the acini being completely filled with contrast. There were also some changes in the upper lobe which was much smaller than normal. Whereas the anterior branch of the upper lobe bronchus (3 in fig. 7) usually runs downwards, it was in this case directed upwards.

SUMMARY

Attention is drawn to the importance of a temporary high position of the diaphragm, causing collapse of the basal parts of the lung. The same effect on the lung may also be caused by other conditions: pleural lesions, tumours etc. Illustrative bronchographic studies are presented. The "naked filling" of the larger bronchi is very characteristic; this picture is often mistaken for bronchiectasis.

ZUSAMMENFASSUNG

Es wird auf die Bedeutung einer vorübergehenden Hochstellung des Zwerchfelles aufmerksam gemacht, wodurch ein Kollaps der basalen Lungenabschnitte hervorgerufen werden kann. Der gleiche Effekt kann auch unter anderen Bedingungen zustande kommen und zwar durch Pleuraschädigungen, Geschwülste u. s. w. Bronchographische Studien, welche dieses beleuchten, werden vorgelegt. Die „naked filling" der unteren Bronchen ist sehr charakteristisch. Dieses Bild wird oft irrtümlich als Bronchiektasie gedeutet.

RÉSUMÉ

Les auteurs attirent l'attention sur l'importance d'une surélévation temporaire du diaphragme causant un collapsus de la base pulmonaire. Le même effet peut résulter d'autres causes: lésions pleurales, tumeurs. Présentation de bronchographies. L'aspect «dépouillé» (en arbre mort) des grosses bronches est très caractéristique; cette image est souvent prise à tort pour des bronchectasies.

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FROM THE INSTITUTE OF ZOOPHYSIOLOGY (DIRECTOR: PROFESSOR PER ERIC LINDAHL), UNIVERSITY OF UPPSALA, SWEDEN

OSMOTIC PRESSURES OF WATER-SOLUTIONS OF METHYLGLUCAMINE-UMBRADIL (3, 5-DIIODINE-4-PYRIDON-N-ACETIC-ACID) MIXTURES

by

J.-E. Kihlström

Introduction

For studying the specific density of sperm cells (LINDAHL and KIHLSTRÖM 1952) the methylglucamine-'salt' of Umbradil was used as a physiologically inert and suitably dense substance. To be able to estimate the influence of concentrated solutions of this substance, it was necessary to determine the osmotic pressures of various concentrations of the 'salt'. The spermatozoa did not show any signs of damage after being suspended in concentrated solutions for half an hour. Because of the use of this substance as a roentgen contrast medium the data obtained should be of clinical interest.

Material and Methods

The solutions used for these determinations consisted of one part of Umbradil and two parts of methylglucamine in distilled water. With these proportions we obtained osmotic pressures equal to those of the mixture used for clinical purposes. In some experiments the Umbradil, which had been stored in a dry state for about one year, was used.

As Umbradil-salt solutions do not have a well definable freezing point and are not stable when heated, the methods generally used in determining osmotic pressures could not be applied. Because of this, a method of determining vapour-pressure lowering, according to WRIGHT (1919), was used with slight modifications. WRIGHT worked with diluted solutions,

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in which the specific density was approximately = 1. In the present investigation the specific densities of the solutions were obtained by weighing the latter in a pyknometer. Instead of weighing the solution flask in order to obtain the concentration of the solution in question, this was determined by evaporating the solvent from a known volume of the liquid. The concentration was expressed as the dry weight of the 'salt' calculated in percentage of the total weight. The difference between the two liquid surfaces has been measured by a ruler graded in half millimetres.

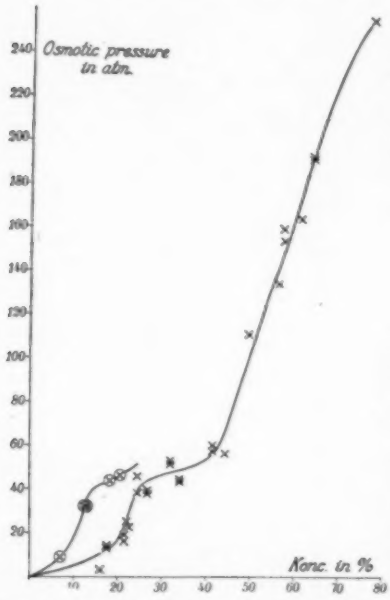

Fig. 1. Osmotic pressures in atm. plotted against concentrations. The encircled points are determined from stored umbradil.

In calculating osmotic pressures use was made of the following formula

$$P = \frac{R \cdot T}{V^1} \ln \frac{p}{p^1}; \quad \ldots\ldots\ldots (1)$$

(P = the osmotic pressure, R = the gas constant, T = absolute temperature, V^1 = the partial molar volume of the solvent in the solution, p = the vapour pressure of the solvent, p^1 = the vapour pressure of the solutions). This gives an approximate value within an error of one per cent. Usually two determinations per sample were made. The mean of these members of pairs, the smaller one expressed as percentage of the greater is 98.7 ± 1.3. In all, 31 values were obtained, 28 of which deviate less than $\pm$ 12 percent from the curve drawn in Fig. 1.

The molecular weight of the solute was calculated according to the usual formula,

$$M = \frac{pSm}{(p - p^1)s}; \quad \ldots\ldots\ldots\ldots\ldots (2)$$

(M = the molecular weight of the solute, m = the molecular weight of the solvent, S = the weight of the solute, s = the weight of the solvent.)

Of course water is not an ideal solvent for this purpose because of its low molecular weight and low vapour pressure. In the examples in the original paper by WRIGHT (1919), in which solvents with higher molec-

ular weights and thus higher vapour pressures than those of water were used, the average error was about 6 per cent. Using water we must take a greater error into consideration, which, however, is diminished by the modifications of the method used in this case.

Results and Discussion

The data obtained are presented in Fig. 1, in which the osmotic pressures observed are plotted against the concentrations. As seen, the curve consists of two different parts, both having an upwardly concave form, their connection lying at a concentration of 26 per cent and a pressure of about 40 atm.

Above this critical point calculations of the molecular (particle) weight give a mean of 306, and below it, 253. Umbradil and methylglucamine according to their structures are considered to have molecular weights of 405 and 193 respectively. If these proportions between the components were used, *i. e.* four molecules of methylglucamine per molecule of Umbradil, an average particle weight of 235 would be expected. It is apparent from these figures that even in solutions of comparatively low concentrations, an aggregation between the components, increasing the mean particle weight above the value calculated from the chemical formulas, occurs. At the critical point the aggregation increases. In addition, the particle weights obtained do not show any correlation to the concentrations.

In Fig. 1 the encircled points are determined from solutions in which the acid part had been stored in a dry state for one year. These points give a curve also consisting of two upwardly concave portions, both being displaced towards lower concentrations in relation to the curve of freshly manufactured Umbradil. This alteration indicates that changes have occurred during storage. The mean particle weight calculated from the points of the lower portion of the curve obtained with aged Umbradil is 113 which indicates a diminution of the mean particle size.

ADAIR (1928) found an upwardly concave curve when dealing with the osmotic pressures of concentrated haemoglobin solutions. He showed that this type of curve probably depends upon forces interacting between molecular aggregations and may be represented by applying the equations of HIRN and VAN DER WAALS. It seems very probable that the curves plotted by the present writer may also be represented by these equations.

Acknowledgements

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SUMMARY

The osmotic pressures of water solutions of Umbradil-salts, ranging from 6.7 to 78.3 per cent, are determined and presented in a curve, some properties of which are discussed.

ZUSAMMENFASSUNG

Der osmotische Druck in Wasserlösungen von Umbradilsalzen, die zwischen 6.7 % und 78.3 % variieren, ist untersucht worden. Die Ergebnisse werden kurvenmässig wiedergegeben und diskutiert.

RÉSUMÉ

L'auteur a mesuré les pressions osmotiques de solutions aqueuses de sels d'Umbradil de 6.7 à 78.3 pour cent. Il les a représentées par une courbe dont il étudie certaines propriétés.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR: P. M. KJELLAND), HEDMARK COUNTY HOSPITAL, ELVERUM, AND THE ROENTGEN DEPARTMENT (DIRECTOR: D. GJERDING), STAVANGER CITY HOSPITAL, STAVANGER, NORWAY

THE RELATIONSHIP OF THE EFFECT AND PAIN OF PREGNANCY TO THE ANATOMY OF THE PELVIS

by

Egil Farbrot

Introduction

Pregnancy and childbirth among civilized peoples are unfortunately not always the physiologic processes nature intended them to be. The unpleasant truth is that many pregnant women develop pain in the back and often in the lower extremities. The pain frequently continues after childbirth and may be increased by a further pregnancy; it may in some cases constitute a direct cause of invalidism. It is characteristic of the common view of these conditions that pain in the back originating during pregnancy is frequently not considered pathologic. The purpose of this study is therefore, to see whether any roentgenologic changes in the pelvis are brought on by pregnancy, and to attempt to show whether a relationship exists between such changes and the pain of pregnancy.

History

The belief that the symphysis pubis becomes softened and "stretched" during pregnancy is old. Around about 1600, a French anatomist described palpable mobility of the rami of the ossa pubica in a gravida who had been executed. In 1875 BUDIN reported that of 80 pregnant women examined all showed some mobility of the symphysis on palpation. This continued after childbirth in only a few cases. DALE and SKAJAA (1929) demonstrated roentgenologically an increase in the width of the symphysis during pregnancy as well as a fairly common osteoporosis of the ossa pubica. HEYMANN and LUNDQVIST (1932) roentgenologically examined 70 women during pregnancy and 8 during childbirth and found that the symphysis increased in width without exception during pregnancy. The increase began early, ceased 2—3 weeks before childbirth, and

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disappeared after delivery. ROBERTS (1934) showed a vertical stretching together with a slight increase (25 % in primiparae) in the breadth of the sacro-iliac joints which after delivery almost always returned to the pregravid size.

Little is found in the literature concerning the condition of the posterior part of the pelvis, particularly regarding the sacro-iliac joints and the angle of the sacrum, in pregnancy and childbirth.

BARSONY and POLGAR (1929) described a condition, which they called ostitis condensans ilii, consisting of a sclerosing bone process of the ilium on the lateral aspect of the sacro-iliac joint. The authors considered the sclerosis in most cases to be an independent condition but found it also secondary to hip-joint disease. The incidence of the disease in the two sexes is not mentioned in their study. SEMB and FRIMANN-DAHL (1937) published a further investigation of sclerosis of the sacro-iliac joint, the material consisting of six men and three women. Static changes such as possible differences in the level of the symphysis, slanting pelvis and scoliosis were considered important in the pathogenesis. The authors noted that in two of the three women with traumatic sacro-iliac disease after pregnancy, slight sclerosis of the margins of the joint was present.

The significance of the angle of the sacrum in the pathogenesis of low back pain has also been given little attention. SCHMORL and JUNGHANNS in 1932 wrote that the angle shows no important variation with advancing age nor in the two sexes. The authors discuss various clinical reports from which it appears, somewhat inconclusively, that a horizontal position of the sacrum may cause low back pain and that the angle may be increased after trauma.

BROOKS (1934) discussed the part played by the sacro-iliac joint in the development of low back pain. He concluded that certain conditions such as pregnancy and muscular atrophy are followed by non-physiologic irritation of the ligaments, more pronounced as the angle of the sacrum is increased, and accompanied by pain. His hypothesis was that the angle was labile and dependent upon the load. In the literature based upon clinical observations one finds CEDERSCHJOLL's description (1839) of the painful conditions caused by softening of the symphysis. SKAJAA (1929) reported 31 out of 185 patients (16 %) with "Relachement douloureux des symphysis du basin". SKAJAA distinguished between: a. Pain situated in the symphysis pubis and radiating downwards to the anterior regions of the thighs. b. Pain situated in the lower back and radiating to the hips. All pain disappeared post partum except for one case in SKAJAA's study. GENELL's communication published in 1948 reported 92 patients, or 1 % of his series, with signs of "Insufficientia pelvis gravidarum et puerperarum". GENELL says of the pathogenesis, "It is considered probable that in the background there is either a constitutional weakness in the pelvis and its supporting and motor apparatus, or an abnormally high incretion from the placenta."

Neither of the two latter authors claims to have had any particular aid from roentgen examinations. SKAJAA wrote concerning the symphysis pubis: "The only characteristic change seen in roentgen films is a fraying of the borders between the bone and cartilage, but this was seen in only some of the cases." GENELL concluded from his own experience and the reports of others: "Thus the roentgen examination affords no aid in the diagnosis, and I have therefore omitted it in the majority of cases."

The Material

The material was collected from 1949 to 1951, a part at Hedmark County Hospital, the larger part at Stavanger City Hospital. Several of the patients summoned for supplementary examinations failed to keep their appointments, and the material has therefore

lost some of its continuity. However, 131 parae examined both clinically and roentgenologically are included in the main body of the material; 90 were received directly from the obstetric department for examination, while the remainder were referred from the out-patient department.

In addition to the main group, over 250 cases examined are placed in a general group which includes those whose examinations were incomplete either because they did not appear for supplementary examinations or because only the symphysis pubis or the sacro-iliac joints were examined. This group serves as a basis for observations in the main group. Some nulliparae and men are also included for comparison.

An important problem was to evaluate the type and degree of pain and to determine whether there was actually a characteristic pain of pregnancy. The criteria used were: Pain described as originating during pregnancy in a patient without previous back complaints and of such intensity as to reduce her activity. If the pain recurred during a subsequent pregnancy and especially if it persisted between pregnancies, these facts were decisive. Those whose pain was occasional or who complained of fatigue centered in the back were not included. Pain which was markedly increased during pregnancy was included even though some pain had existed previously.

In conclusion it may be noted that the average age for onset of the pain was 25.3 years. This group can hardly have important spondylosis symptoms nor should there be muscle pain caused by increased body weight; in other words, these patients should not be predisposed to other diseases of the back.

Method

The symphysis pubis in all cases was examined in the standing position with the weight borne first on the right and then the left leg. Since the load is the weight of the body, this gives adequate expression of the daily load on the symphysis pubis. In gravida, the cassette could not be placed directly over the symphysis as in the non-gravida; on the assumption that the thickness of the patients varies but little, the size of the image may be reduced by simple calculation to what it would be if obtained with the cassette in the normal position. The vertical stretching of the symphysis then becomes the maximum distance between the upper medial margins of the ossa pubicae under the shifting load. It is not feasible to demonstrate whether the mobility may be greater in other planes, *i. e.* in the rotated pelvis. In any case it is probably the stretching in the vertical plane which is the most important as regards the position of the pelvis. The symphysis pubis usually has a constant breadth from above downwards. If not, the mean of the maximum and minimum width was used. It became evident that the height of the ossa pubicae varied considerably. As an expression for the anatomic stability of the symphysis pubis, the author used the term "symphysis quotient", by which was meant the relationship between the height and breadth of the symphysis. The higher the quotient, the less cartilage present, and thus the greater the stability.

The films of the sacro-iliac joints were taken in the usual manner with the patient in the supine position and the tube centered over the

symphysis and tilted 30° in a caudal direction. The width of the joint was measured at its lowest part where the joint space was projected free. It was not found necessary to take special views as a few trial projections at the beginning of the study did not appear to give more information than the routine films. The main purpose was the evaluation of sclerosis. The terms used were "clean joint" where normal bone tissue was found up to the joint cartilage, "subsclerosis" where there was a narrow area of sclerotic bone tissue adjacent to the joint cartilage and "sclerosis" where there was marked density *i. e.* pathologic along the sacro-iliac joint. All the joints were evaluated at least once without previous knowledge of the sex or case history. The sacrum and the sacro-iliac articulations, which bear the weight of the body, form different angles with the vertical plane in various subjects. This angle between the axis of the body of S. 1 and the vertical plane with the patient in the standing position, was therefore determined and is called the "static angle of the sacrum" (instead of the "non-static angle" used earlier). All lateral films of the sacrum were taken with the patient in a natural standing position with the arms a little forward. The vertical line was marked on the film.

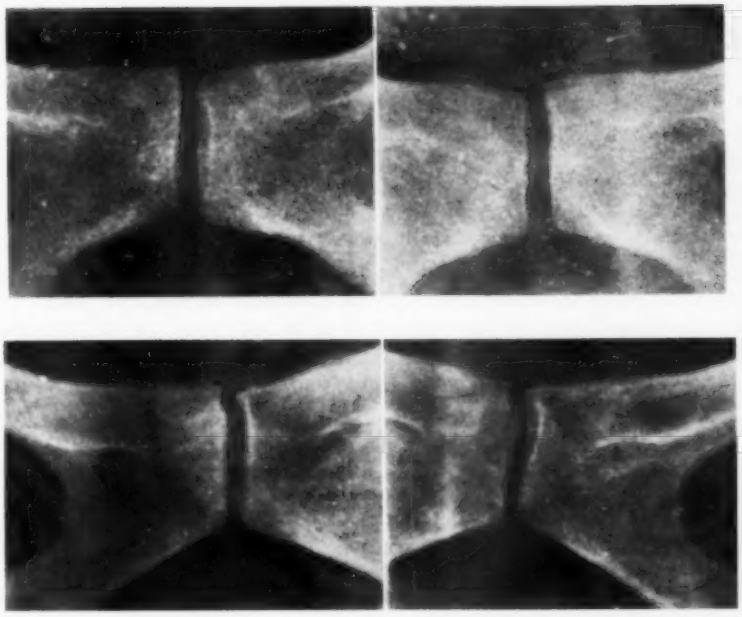
It would have been desirable, in addition, to measure the angle of the sacrum in relation to the pelvis to ascertain whether this be actually increased during pregnancy (because of softening). As there are no distinguishing points in the pelvis on which to base this measurement, the datum seems to be impossible to obtain.

From a number of control examinations it appears that small differences in technique do not make any appreciable difference in measuring the vertical stretching of the symphysis or the static angle of the sacrum.

The Symphysis Pubis

The symphysis pubis was examined in a total of 286 cases, 211 being parae, 37, nulliparae and 38, men.

The measurements, taken in the parae six months or more after the last delivery showed, in 205 cases, a definite displacement varying from 1 to 17 mm (the latter after rupture) with an average increase of 2.5 mm (Fig. 1). Thus vertical stretching was found in 97.2 % of all parae. The measurements were taken up to 36 years after the last childbirth with an average of 5.8 years. Ten measurements were obtained approximately 30 years after the last delivery. There were 24 post-climacteric parae with an average age of 56.3 (50 to 74 years of age). Only one of this group was normal. The remainder showed deviations of from 1 to 6 mm with a mean average of 3.1 mm. This indicates that



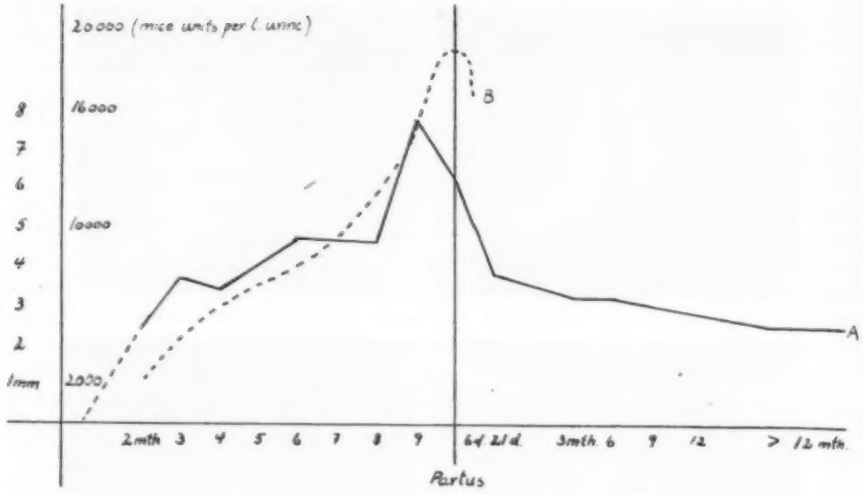
a.

b.

Fig. 1. a. Symphysis with 4 mm vertical stretching in para 2 years post partum.
b. Symphysis in nullipara with no stretching.

when movement has occurred, it is permanent. The six parae showing no increase, exhibited no signs which might explain its absence.

An attempt was made to determine whether there were mechanical or other conditions which influence the amount of deviation. The body weight exercises no effect. No reduction of the stretching with increasing years after the last childbirth could be proved. On the other hand it appeared that there was a certain vertical stretching of the symphysis corresponding to the number of children borne, at least after a total of 4 or 5 was reached. Likewise there was a certain relationship between the opening of the joint and weight of the fetus, a large fetus producing a somewhat greater amount of stretching than a small fetus. If forceps were used or the delivery was more difficult than usual, a larger amount of stretching was found than in normal deliveries. The symphysis quotient and breadth had no demonstrable effect upon the stretching, and the same was true of the size of the angle of the sacrum.



A. B.

Diagram 1. A. Mean variation of movement before and after delivery (based on 446 measurements of 244 women).
B. Estrogen excretion in pregnancy (Koff).

In gravidae and puerperal women the examination was carried out several times in order to follow any changes. Sixty examinations were made of 51 pregnant women and 376 examinations of 193 puerperal women. The results appear in Diagram 1. Symphysis stretching (A) begins early. At the end of the second month of pregnancy it is marked and increases steadily to an average of 7—8 mm at its peak a month before delivery (varying in width from 2.4—11 mm); it appears to be slightly reduced during the last month. During the three months after delivery most of the reduction of the displacem nt has taken place. After one year the stretching has been reduced to an average of 2.5 mm and so remains, apparently for the rest of the woman's life. In the diagram, the curve (B) for the excretion of estrogen during pregnancy has been drawn in. There is a marked similarity between it and the curve for symphysis stretching, a fact which strongly points to a cause and effect. A marked relationship between the increase in the joint space in the first post-partum days and one year later (62 parae) was also found. Therefore it seems justifiable to assume that a large increase in the displacement seen some time after delivery means that a correspondingly large increase took place during the preceding pregnancy.

In studying the roentgenologic appearance of the rami of the ossa

pubica in the 131 patients in the main group, 51 (39 %) showed changes: 18 had decalcification, 31 sclerosis and 2 combinations of these. The signs disappeared in only 3 in the course of one year, while in the others they appeared more permanent. The displacement of the symphysis in these cases one year post-partum was 3.1 mm, *i. e.* somewhat larger than the average for all parae. Pain in the joint and changes in the rami as described by SKAJAA were found in 14 of all parae. They had furthermore an average movement of 4.5 mm, one year post-partum — considerably over the average. The three ruptures of the symphysis, diagnosed clinically, are in this group. Splitting of the cartilage, on the other hand, apparently occurred at random. Probably marked stretching of the symphysis together with irritation of the rami as evidenced by decalcification and sclerosis predispose to pain. It is often surprising to note the large amount of displacement of the symphysis pubis which occurs in the latter months of pregnancy without producing pain. As far as could be determined there was no relationship between changes in the symphysis and lumbar pain.

The mean width of the symphysis in parae six days post-partum was found to be 6 mm and one year post-partum 4.1 mm (as compared to 3.4 mm in nulliparae).

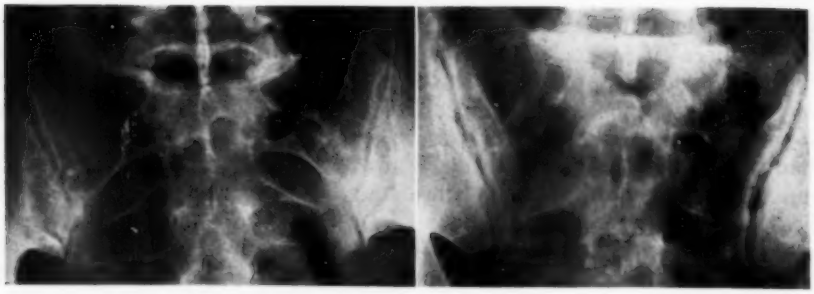
Of the 286 patients examined 37 were nulliparae and 38 men, a total of 75 who had not borne children. Three of the women had displacement of 1 mm and one of 2 mm (childbirth not disclosed?). One man had a 3 mm displacement of the symphysis pubis, an interesting fact since he had been treated with large doses of Stilbofolin followed by a reaction in the mammary glands. When this case is excluded only 5.4 % of the cases (compare with 97.2 % in the parae) in the group showed evidence of changes.

The examination of 286 patients for the purpose of determining whether pregnancy has occurred at some time by the presence or absence of symphysis stretching will thus give a 96.5 % correct result.

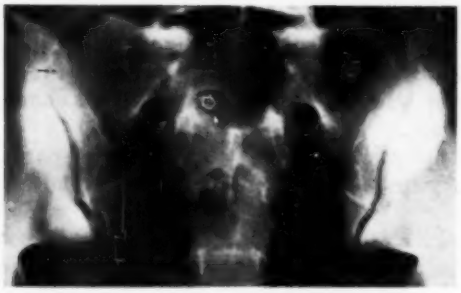
No appreciable difference in the basic width or quotient of the symphysis pubis between parae on the one hand and nulliparae and men on the other, was found.

The Sacro-iliac Articulations

Three hundred and eleven sacro-iliac joints were examined, some on several occasions, and distributed over 211 parae, 25 nulliparae and 74 men. Using the terms previously suggested only 6 men were found with subsclerosis, the remainder having clean joints, *i. e.* 93.2 %. With the exception of the patient who had undergone Stilbofolin treatment and who had both subsclerosis and movement of the symphysis pubis, there



a. b.



c.

Fig. 2.
a. Clean sacro-iliac joint in nulliparа.
b. Subsclerosis in para.
c. Sclerosis in para.

were none who had vertical stretching. Four of the 26 nulliparae had subsclerosis, all without displacement; 84.6 % had clean sacro-iliac joints. A total of 90 % of the men and nulliparae together had clean sacro-iliac joints.

The conditions in the 211 of the para group were diametrically opposite; only 14 clean joints were found. The remaining 197 (93.4 %) showed subsclerosis or sclerosis. (Fig. 2.)

The following facts in regard to the 14 clean joints were noted: five patients had had only one pregnancy, one had had two pregnancies and 8 had been delivered on an average 19 years previously. It is possible that the above facts had something to do with the "absence" of subsclerosis. The symphysis was examined in 173 of this group. All showed evidence of displacement.

Sclerosis and subsclerosis thus occur in the large majority of parae. This is true for 92 % of the total 311 sacro-iliac articulations examined.

The sclerotic processes were found only on the iliac aspect of the joint in almost all cases. In only 12 cases, 6 with marked sclerosis, was there any additional sign of increased density on the sacral aspect. In

7 cases the subsclerosis was found only in the lower part of the joint. The rest of the cases all showed subsclerosis or sclerosis in the middle of the joint with a symmetric spreading upwards and downwards. In 9 of the most marked cases the entire joint was involved. It was noted furthermore, that the position of the joint surfaces in relationship to the sagittal plane did not appear to have any bearing upon the development of the sclerosis. In this connection it may be of interest to add that no convincing sign of softening of the cartilage of the sacro-iliac joint was found. A large number of articulations were examined a short time after delivery and again about one year post partum. No measurable variation in the width was found.

Among the 131 satisfactorily examined parae a total of 33 (12.1 %) were found to have marked sclerosis. The sclerosis occurred as follows: twenty-one in patients with otherwise negative roentgen findings, 10 combined with a 'diminished' 5th lumbar disc and 2 with transitional lumbosacral vertebra. The average degree of symphyseal displacement for the sclerosis group was 3.5 mm (average for the entire para group 2.5 mm), and the average width of the sacro-iliac joint, 2.5 mm (2.3 mm for the subsclerotic group). There was no indication that the number of pregnancies influenced the degree of sclerosis. The sclerosis was apparently permanent.

A clinical study of the sclerosis group showed that 8 had experienced no pain during pregnancy. One of the 3 patients with the most extensive sclerosis had no pain during pregnancy, one had slight low lumbar pain while the other was invalided by this complaint. It thus appears that parae with sclerosis were not more troubled by pain during pregnancy than parae in general. There was distinct tenderness upon pressure over one or both sacro-iliac joints in 10 of these 33 patients (examined on an average 2.4 years post-partum). Two of the patients with the most pronounced sclerosis had no tenderness on pressure. These observations indicate that sclerosis of the sacro-iliac joint is a rather harmless result of pregnancy.

The Symphysis Pubis and Sacro-iliac Articulations Considered as a Unit

The results of the examinations described gave no answer to the question of the pathogenesis of pain during pregnancy. However, they did provide considerable insight into the changes caused by pregnancy in the symphysis pubis and joints of the pelvis. In the symphysis there is a permanent displacement which may be used as a criterion of a previous pregnancy with 96.5 % certainty. The changes in the sacro-iliac joints consist of sclerosis or subsclerosis which indicate presumptive previous pregnancy with 92 % certainty. The actual cause of the increased den-

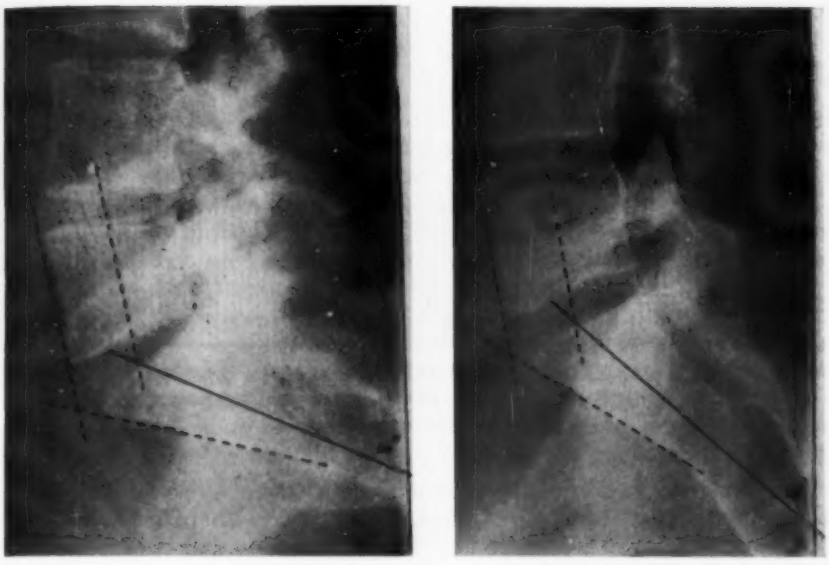
sity in the sacro-iliac joints (and also, in some cases, of the symphysis pubis) was not evident from the examination. Softening as in the symphysis pubis was not found. On the other hand, the sacro-iliac articulations receive greater mechanical stresses and it is possible that even the least softening of the cartilage or the ligaments may permit a small amount of motion, which in turn may create irritation of the bone with resulting sclerosis. This hypothesis is supported by the fact that the group with sclerosis had a somewhat greater displacement of the symphysis (which is assumed to be concomitant with a slight softening of the sacro-iliac joints) than the group with subsclerosis. The somewhat greater movement of the symphysis (in the group with sclerosis) in itself causes abnormal mobility, or at least abnormal tension in the sacro-iliac joints and their ligaments. Any weakness in one of the articulations of the pelvis must necessarily result in greater stresses upon the other joints. The importance of the static angle of the sacrum in the development of sclerosis is problematic. However, a mean average of 60° was measured in the parae with sclerosis, a fact which is assumed to result in a functionally less resistant joint than when the angle is smaller (see below).

Some of the subsclerotic joints, as mentioned, are rather difficult to evaluate. Nevertheless it was found that the examination of the sacro-iliac joints was an important supplement to the examination of the symphysis in determining whether the pelvis was that of a para or nullipara. The combined results provide more information than each singly.

The Static Angle of the Sacrum

Since a study of the symphysis pubis and the sacro-iliac joints gave no plausible explanation of the pain of pregnancy, it was necessary to see if the angle of the sacrum had any significance. One hundred and thirty-one parae were satisfactorily examined (the main group). In order to avoid irrelevant causes of low back pain parae with 'diminished' 5th lumbar disc and transitional lumbo-sacral vertebra were excluded. Six patients with doubtful lumbar spondylosis were included. Four of these had no pain and the other two did not affect the statistics one way or another.

There were 90 parae with what is ordinarily considered roentgenologically normal spinal columns. None of these had lumbar pain previous to pregnancy. 48.8 % had pain during pregnancy (among the 90 chosen at random 38.7 % had pain during pregnancy). In explanation of this high figure we would add that in this study broader indications for the diagnosis were used than those employed by both GENELL (1 %) for the most debilitating cases and SKAJAA (16 %) for a similar material. (See the earlier definition of the term "pain of pregnancy").



a. b.

Fig. 3. a. Para with static sacral angle of 66°.
b. Para with static sacral angle of 48°.

Measurements of the angle of the sacrum in these 90 cases (1 year post partum at the earliest) disclosed firstly that there are great individual variations in the angle — from 41° to 75° with the majority between 45° and 65° (Fig. 3). A similar variation and distribution was found in 8 nulliparae and 21 men. In all groups the angle was as often over 55° as under. For this reason, among others, it is improbable that the angle is greater after pregnancy than before. The relationship of the pain of pregnancy to the size of the angle of the sacrum was next studied, and a marked association between pain and a large angle, as well as absence of pain in the presence of a small angle, found (Diagram 2). Forty-two out of forty-four parae with pain had an angle of over 55° while 40 out of 46 parae without pain had an angle of 55° or less. In other words the statement that a static angle larger than 55° causes pain in pregnancy, and a static angle of 55° or less does not, is 91.8 % correct. These figures are so conclusive that the rule can hardly be discredited by formal objections such as to the small size of the material or the entire material not being chosen at random.

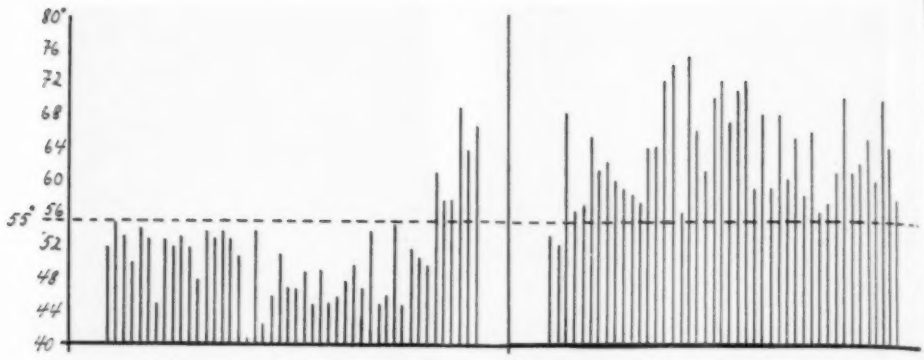


Diagram 2. Left: Parae (46) without pain of pregnancy.
Right: Parae (44) with pain of pregnancy.
Ordinate: Static angle of the sacrum.

A closer inspection of the 9 exceptions to the above rule strengthens the impression of cause and effect. The group with pain showed only 4.5 % exceptions. These were two women with one and two pregnancies respectively. The angles measured 52° and 53° in these cases, and both patients had practised gymnastics. In the no pain group there was a 13 % exception to the rule. Four of these six women had only one child, the other two had two and three children respectively. As will be shown later, pain does not always occur in the first pregnancy; thus it is possible that one or more of the four with only one pregnancy might later experience typical pain. It was further noted that five of the six without pain (in spite of a large static angle) had engaged in systematic exercise before and in a period during pregnancy. In this connection we reviewed the frequency of systematic exercise in the rest of the group (90 parae). The information in four cases is lacking. Only eight of the parae with a static angle of 55° or less had engaged in exercises. The effect upon the pain of pregnancy could not be evaluated. Nine of the parae with an angle greater than 55° had taken systematic exercise and five reported a marked improvement, often noticeable in later pregnancies. Expressed as a percentage, only 24.4 % of all the parae had taken systematic exercise in adult life; 66.6 % of these noticed the benefit during pregnancy. The latter figure must be accepted with some reservation, as it is impossible to ascertain whether the exercises were correctly carried out or were adequate.

The following table further illustrates the importance of the angle of the sacrum in the occurrence of pain during pregnancy. Intensity of pain graded 1, 2 and 3 (3 incapacitating):

Grade 1 — 26 parae ..... average static angle 62°
Grade 2 — 15 parae ..... » » » 63°
Grade 3 — 3 parae ..... » » » 67°

Furthermore, on examination one year post-partum five of these forty-four parae were free from pain and four were "uncertain". Thus nine parae had completely or in part recovered. The static angles averaged only 60°, *i.e.* the degree of angulation appeared to be in direct ratio to the intensity of pain and in indirect ratio to the possibility of recovery. Closer comparison of the two groups, those with and those without pain, produced a negative result. The average number of pregnancies was 2.6 and 1.8 respectively. The largest number of deliveries without pain was six while on the other hand there were 32 primiparae who had pain. There was no marked difference in the type of physique. The average weight of all new-born in the group with pain was 3.7 kg (3.5 in the group without pain). The average time in bed post partum was 3.7 days (3.5 for the no pain group). In the group with pain there were 32 in whom pain began during the first pregnancy, 11 in the second, and one in the third pregnancy.

For the sake of completeness a review of the remaining 41 parae in the main group as regards pain in pregnancy must be included.

31 had a 'diminished' 5th lumbar disc, in most cases of moderate degree.

16 out of the 31 parae had a static sacral angle of over 55°.

8 of these had no pain previously but developed pain during pregnancy and continued to have pain post partum, whereas 5 had a marked increase in pain during and after pregnancy, and 3 had no pain at any time.

In brief: 13 out of 16 parae with a 'diminished' 5th lumbar disc combined with a static angle of over 55° had pain in pregnancy.

The remaining 15 parae had a static angle of 55° or less. Five of these had no pain. Two had pain before, during and after pregnancy. Eight had no pain before but only during and after pregnancy. Thus 8 of 15 parae with a 'diminished' 5th lumbar disc had developed pain in pregnancy despite a static angle of 55° or less. In these cases it is reasonable to place at least some of the blame upon the 'diminished' disc. 24 % of the parae had a "diminished" 5th lumbar disc.

Transitional lumbo-sacral vertebrae were found in 10 parae (8 %), 7 having unilateral and 3, bilateral sacralization. The static angle of the sacrum could not be measured in these cases. However, it was remarkable that 9 of the 10 had no pain previous to pregnancy, and two completed pregnancies without it developing.

In conclusion we shall review briefly a few details concerning the type of pain and the clinical signs.

A total of 73 of the entire group of 131 parae had pain during pregnancy classified as follows:

Low lumbar pain 50
Low lumbar pain and symphyseal pain 14
Low lumbar pain and sciatic pain 9

Eight of the latter 9 had a 'diminished' 5th lumbar disc; in 7 cases sciatica occurred in direct association with pregnancy; in the other two cases it arose somewhat later. These facts may indicate that pregnancy also has an untoward effect upon the 5th lumbar disc. This view is supported by the fact that of the 88 cases chosen at random, a 'diminished' 5th lumbar disc was found twice as frequently among parae as among nulliparae in the 30—50 age-group.

In 61 of the 90 patients with normal backs, pregnancy pain appeared to occur twice as often in rural areas as in towns.

A survey of the clinical signs showed that Lasègue's test was positive in only 3 cases (all 3 had sciatica). Trendelenburg's test showed no insufficiency in any case. Tenderness over a sacro-iliac joint was found in 26 parae, tenderness over the symphysis in 12.

But few of the parae were examined during the acute stage, so that these figures do not give an adequate picture of the clinical signs. However, the sum of the findings indicates that neither a positive Lasègue's test nor Trendelenburg's test insufficiency belongs to the picture. Trendelenburg's test insufficiency was not expected, as the softening of the sacro-iliac joint, its only possible cause, would then have been so marked as to have been disclosed when it was examined.

Pathogenesis of the Pain of Pregnancy

In order to give a plausible explanation of the relationship between the static angle of the sacrum and pregnancy pain it is necessary to assume a purely static anatomic viewpoint. It is not likely that the hormonal softening of the symphysis pubis and articulations of the pelvis within normal limits can produce the pain encountered. The sacro-iliac joints present oblong articulating surfaces surrounded by strong ligaments, particularly posteriorly. Each joint must necessarily be most resistent to stress along its length where both its surfaces and ligaments provide maximum resistance. The resistance to stress, for instance across the short axis, is reduced. The stress upon the sacro-iliac joints follows a vertical path via the spinal column and is represented primarily by the weight of the body. Thus it is clear that the more acute the sacral angle, the closer the long axis of the sacro-iliac joints lie to the centre of the body weight, enabling greater strain to be withstood. Another contributing mechanical fact is that the sacrum may be considered as a lever with the axis somewhere in the sacro-iliac articulations and with the spinal column and body weight situated upon the anterior arm of the balance. The larger the static angle of the sacrum, the longer the arm of the balance becomes and the greater the stress upon the joints.

A large static angle in itself does not produce low lumbar pain; pregnancy must be superimposed. It then appears that the softening of the cartilage of the symphysis pubis (and possibly the cartilage of other pelvic joints) increases the stress upon the sacro-iliac articulations. In addition there is the question of the musculature. Two muscle groups are especially important, the long extensors of the hip and the abdominal muscles; these together prevent a horizontal position of the sacrum, primarily by indirectly inhibiting an anterior rotation of the pelvis; a direct pull on the lower posterior edge of the sacrum by the hip extensors and the ligaments around the sacrum may also take place. As a rule there is marked insufficiency of the abdominal musculature during pregnancy and after. The hypotonic and wasted abdominal wall in parae is well known. This appears to be an important cause of pregnancy pain, perhaps the most important. The abdominal musculature is more or less passive in daily life and the usual activities. Some degree of wasting from inactivity is probably common in civilized peoples. Pregnancy increases the muscle insufficiency, the sacro-iliac joints thereby lose some of their natural protection, and in the least resistant articulations, namely in patients with large static sacral angles, the stress and irritation pass physiologic levels, and the pain of pregnancy is established. The information, though limited, concerning systematic exercise in this material indicates that this view of the pathogenesis may be correct. In this connection, Lövseth's gymnastic regimen for pregnant women is of interest.

If the foregoing view of the pathogenesis of pregnancy pain be correct, it should be possible to institute prophylactic measures to prevent its development. However, it is not within the scope of this study to discuss prophylactic and therapeutic problems.

Conclusions

A. Every gravida with a static sacral angle of over 55° is pre-disposed to pain during pregnancy.

B. There is considerable evidence to indicate that the pain may be reduced or relieved by maintaining the tone of the abdominal musculature (and the extensors of the hips) both during and after pregnancy.

C. Measurement of the static angle of the sacrum may possibly have diagnostic value in parae who suffer from low lumbar pain without adequate roentgenologic or clinical signs. It is possible that many back afflictions previously considered indefinable may have a demonstrable anatomic basis.

SUMMARY

The roentgenologic examination of the pelvis in a material of parae as well as nulliparae and men is discussed. During pregnancy a degree of vertical stretching of the symphysis pubis was shown to occur; it was reduced post partum but never entirely disappeared. In parae sclerosis or subsclerosis in the region of the sacro-iliac joints was also demonstrated; these changes were rarely found in nulliparae or men. It may thus be determined at any time with only a slight chance of error whether or not a woman has ever had a pregnancy. Measurements of the static sacral angle showed that parae with an angle of over 55° developed pregnancy pain, while parae with an angle of 55° or less remained free.

The importance of the musculature in the pathogenesis of pregnancy pain is discussed and the conclusion drawn that women with a static sacral angle of over 55° should make an effort to maintain the abdominal musculature during pregnancy. Measurement of the static angle may also be of importance in establishing the diagnosis in cases of inexplicable low lumbar pain.

ZUSAMMENFASSUNG

Die Röntgenuntersuchung des Beckens von Parae, Nulliparae und Männern wird diskutiert. Es wird gezeigt, dass während der Schwangerschaft ein schrittweises Gleiten der Symphyse auftritt; es wird nach der Entbindung wieder geringer, verschwindet jedoch niemals völlig. Bei Parae wird ebenfalls eine Sklerose und Subsklerose in der Gegend der Sakroiliacagelenke demonstriert; diese Veränderungen fand man bei Nulliparae oder bei Männern selten. Zu jedem Zeitpunkt kann man infolgedessen mit einer ganz unbedeutenden Reservation entscheiden, ob eine Frau eine Schwangerschaft durchgemacht hat oder nicht. Messungen des statischen sakralen Neigungswinkel ergaben, dass Parae mit einem Winkel von mehr als 55° Schmerzen während der Schwangerschaft bekamen; bei einem Winkel von 55° und darunter traten derartige Schmerzen nicht auf.

Die Bedeutung der Muskulatur für die Pathogenese der Schwangerschaftsschmerzen wird diskutiert und der Schluss gezogen, dass Frauen mit einem statischen sakralen Neigungswinkel von mehr als 55° während der Schwangerschaft für eine gute Bauchmuskulatur sorgen sollten. Messungen des statischen Neigungswinkels dürften auch zur Sicherstellung der Diagnose in Fällen mit unerklärlichen Schmerzen in der unteren Lendengegend wertvoll sein.

RÉSUMÉ

L'auteur a étudié les aspects radiologiques du bassin, d'une part chez des femmes ayant accouché, d'autre part chez des nullipares et chez des hommes. Il montre que pendant la grossesse survient une certaine distension de la symphyse pubienne qui diminue après l'accouchement mais ne disparaît jamais entièrement. Il met de plus en évidence chez les femmes qui ont accouché une sclérose ou une sclérose légère de la région des articulations sacro-iliaques, qu'on ne trouve que rarement chez les nullipares ou chez les hommes. A n'importe quel moment de la vie d'une femme on peut donc sur cette donnée et presque à coup sûr savoir si cette femme a été enciente ou non. Les mesures de l'angle d'inclinaison du sacrum en station debout montrent que les accouchées chez qui il est supérieur à 55° ont eu des douleurs pendant leur grossesse, alors que celles qui avaient un angle égal ou inférieur à 55° en furent exemptes.

L'auteur examine l'importance de l'état de la musculature dans la pathogénèse des douleurs de la grossesse et conclut que les femmes qui ont un angle sacré statique de plus de 55° devraient s'efforcer de maintenir leur musculature abdominale pendant leur grossesse. La mesure de l'angle statique peut aussi être importante pour établir le diagnostic dans des cas de lombalgie basse inexplicable.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR: H. SAHLSTEDT), LASARETTET, FALUN, SWEDEN

ECTOPIC URETER

Report of a Case

by

Hans Eckerbom and *Bengt Liliequist*

Congenital malformations in the urinary tract are relatively common. Ureters opening ectopically are considered one of the rarer forms. According to FRASER (1938) the frequency with which this condition occurs is 1 : 130,000. Slightly more than 300 cases are described in the literature.

In incontinence in women and in all cases of unexplained pyuria in men the possibility of an ectopic ureteric orifice should be kept in mind. Unexplained cases probably exist labelled as enuresis, "paralysis of the urinary bladder" or chronic pyelitis. Correct diagnosis is important, inasmuch as extirpation of the duplicate ureter relieves the patient of symptoms which are often of long duration and psychically depressing. We have observed an instance of this malformation which was unusual in that abdominal aortography assisted in the diagnosis and, judging from the literature for the first time, provided information valuable in the planning and performance of the operative procedure.

Case Report

A woman, aged 45, unipara, no abortions, entered the surgical department of Falu Lasarett in November 1950 for frequency and a burning sensation on micturition together with a certain feeling of heaviness in the genital region of one year's duration. Eight days before admission colicky pains appeared in the lower part of the abdomen, radiating to the lower part of the back. The day before admission the patient's temperature rose to 38.3° C, the pains increasing in severity. Examination of the urinary sediment showed no signs of infection. The non-protein nitrogen was 32 mg per 100 ml. The leucocyte count was 13,200; the sedimentation rate: 18 mm in one hour. Urography disclosed double renal pelves and ureters on the left side, passing separately downwards to the level of the fourth lumbar vertebra. On the right side a rather small renal pelvis

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Fig. 1. Concurrent urography and retrograde filling of the ectopic ureter with contrast medium. The latter passes up to the dilated renal pelvis in the upper part of the right kidney; a normal pelvis is seen inferiorly.

was observed. On gynecologic examination a myoma with signs of necrosis was palpated; this was assumed to explain the symptoms. Supravaginal amputation of the uterus + appendectomy were therefore performed (TOLAGEN). The cystitis symptoms continued, and a few months later a slight prolapse of the anterior vaginal wall was observed. Following further probing of the history it became evident that the patient had had urinary incontinence since childhood.

In October 1951 the patient re-entered the hospital. There was still no sign of infection in the urine. Cystoscopy revealed normal conditions in the bladder, although in the anterior vaginal wall in the midline approximately three millimeters posterior to the urethral orifice an extremely fine fistulous opening was observed; through this urine was seen to flow. A small caliber bullet probe could be introduced through this opening for a distance of 1 cm. When physiologic saline solution was injected into the opening of the fistula, a forward bulging of the anterior vaginal wall was produced. The swelling somewhat resembled a cystocele. Injection of contrast medium through a cannula introduced into the fistulous passage revealed a relatively wide ectopic ureter on the right side, extending up to a rounded, slightly dilated renal pelvis corresponding to the upper part of the kidney.

A repetition of the urography with concurrent retrograde filling of the ectopic ureter with contrast medium showed the anatomic conditions more clearly (Fig. 1, 4).

In order to determine the vascular supply of the right kidney and if possible roentgenologically to demonstrate the demarcation between the normally and pathologically functioning renal parenchyma, lumbar aortography was carried out. On the left side the contrast medium outlined a large kidney; on the right side a rather small kidney. The upper pole of the latter was but poorly filled with contrast medium, and sat like

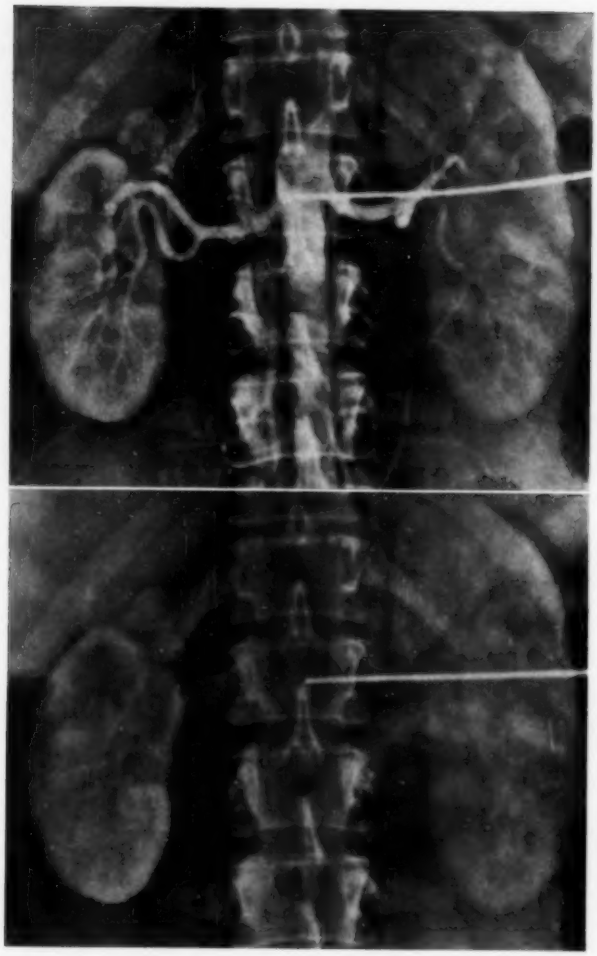

Fig. 2. Aortography. Above: Arterial phase. A small artery from the principal inferior artery supplies the poorly functioning upper pole of the kidney. Below: Nephrogram.

a little hood on the rest of the kidney which, together with the left kidney presented normal appearances. A rather small artery supplying the affected part of the right kidney arose almost at a right angle from one of the larger renal arteries. (Fig. 2.) The defectively functioning part of the right kidney corresponded to the renal pelvis of the ectopic ureter. Urography carried out in conjunction with the aortography showed extremely poor filling of the pathologic renal pelvis.

Operation (TOLAGEN): The kidney and both its ureters were exposed. The extra ureter, which was the thickness of a finger and thick walled, originated from the upper pole of the kidney. The upper pole felt firmer than the rest of the kidney from which it was separated by a slight depression. The small vessel supplying the upper part of the kidney was ligated and the diseased part of the kidney extirpated. Most of the ureter was at the same time removed; only the lower stump was left, to be removed later per vaginam if necessary.

Histologic examination showed the structure of the ureter hardly to deviate from the normal. The extremely hypoplastic extra kidney exhibited alternately a well preserved and an exceedingly shrunken or rudimentary parenchyma. In places, numerous small cysts were observed (GELLERSTEDT).

Embryology: Both ectopic and normal ureters arise from the mesonephric (wolffian) duct. The normal ureter develops as an outgrowth from the caudal part of the wolffian duct. This bud grows dorsocranially where, during the dichotomous branching, it meets the metanephros and induces the development of the normal kidney. The extra ureter may arise either through an early division of the ureteric diverticulum or through the development of two separate rudiments. Of these the caudal part becomes connected with the caudal part of the kidney and the cranial, which forms the extra rudiment, with the cranial part of the kidney. In rare cases the latter portion may develop into a separate extra kidney. During the later development the extra ureter follows the wolffian duct and may thus open anywhere into any of its derivatives. In men these consist of the vas deferens, the seminal vesicles, the ejaculatory duct and the prostatic part of the urethra. In women, on the other hand, the ectopic ureter usually opens into the mid or lower part of the vagina, the urethra or Gartner's duct (fig. 3). However, numerous cases are described in which the orifice of the ureter opened into the upper vagina, cervix or uterus. These parts arise from the paramesonephric (müllerian) duct. Such cases are explained by a rupture having caused a connection between Gartner's duct and the cervix or vagina.

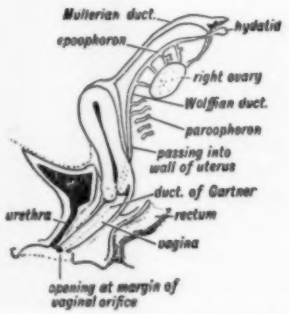

Fig. 3. Schematic picture showing the course of Gartner's duct. After Albert B. Meads.

Ureters opening into the rectum are considerably more rare and seem to be explained only by a more profound disturbance in the division of the primitive cloaca.

Pathology: The majority of malformations occur in women. Of 170 cases collected by THOM (1928), 61 were men and 117 were women.

Fig. 4. Retrograde pyelography. The orifice of the ectopic ureter opens into the vagina.

In the men the orifice of the ectopic ureter opened into the prostatic urethra in 33 cases, into the seminal vesicles in 17, into the vas deferens in 6 and into the ejaculatory duct in 5. In the women it opened into the vestibule of the vagina in 45 cases, into the urethra in 37, into the vagina in 32 and into the uterus in 3. HEPLER reported in 1947 that since 1928 additional cases were described in 3 of which the orifice opened into the uterus, in 13 into the vagina and in 30 into the vestibule of the vagina.

Of the cases observed clinically, 90 per cent are women. According to CAMPBELL (1937) the condition was observed on clinical examination in only nine men.

The ureter with the ectopic orifice is most frequently dilated above the opening. The majority of writers state that the opening is narrow. In that case the dilatation could only be explained as mechanical. CAMPBELL, however, states that the opening is, as a rule, wide, and that the dilatation depends upon a poorly developed musculature of the

ureteric wall. The dilatation is frequently gross; *i. e.*, ureters as wide as the small intestine have been demonstrated at operation. The dilated ureter often arises from a more or less dilated renal pelvis in the cranial part of the kidney. The parenchyma in the corresponding part of the kidney is more or less changed either through faulty development or secondary lesions. In rare cases the parenchyma belonging to the ectopic ureter gives rise to an extra kidney with separate vascularization. Forty-six cases of duplicate kidneys are described, eight with an ectopically opening ureter (LANGLEY, 1949). As in certain other malformations, infections are usual and according to the literature seem to occur in more than 90 per cent of cases. As a rule, microscopic examination reveals both acute and chronic changes in the renal parenchyma and ureteric wall.

Symptomatology: The principal symptoms are incontinence and infection. That the presence of an ectopic ureter may also be entirely hidden by other symptoms is illustrated by a case described by ENGEL in 1948. A 21-year-old man complained of sterility. The cause proved to be an ectopic ureter originating from a hypoplastic kidney and opening into the left seminal vesicle, which was dilated. Incontinence does not occur in men, inasmuch as the orifice of the ectopic ureter always opens proximal to the external sphincter. Infections, pains in the back and bladder, sterility and painful micturition as well as inexplicable pyuria are symptoms and signs which should give rise to suspicion of an ectopic ureter.

In women incontinence is the most common complaint in this condition. As a result the symptoms are misinterpreted and a diagnosis of enuresis in children and paralysis of the bladder in women is frequently made. On closer analysis of the patient's symptoms, however, it becomes evident that the incontinence is superimposed upon entirely normal bladder function. Occasionally incontinence occurs only in the upright position. The explanation of this lies in the fact that the ectopic ureter functions in the recumbent position as a bladder collecting urine. Incontinence is absent in the cases in which the ureter either opens proximal to the external sphincter or passes in the bladder wall and through the sphincter musculature to open into the urethra or the vestibule of the vagina. In this instance the sphincter also regulates the ectopic ureter. Such a case is described by KOLISKO (cit. KILBANE). FITE (1934) and MULHOLLAND (1939) also reported similar cases. In numerous instances the incontinence first appeared after partus, and in a case observed by HARTMAN after the birth of the third child. CASPARI described a case in 1926 in which the incontinence was not constant. In many cases incontinence led to psychic disturbances.

As a rule, the urine in the bladder is normal but, nevertheless, there is frequently a purulent discharge from the vulva. Tenderness on palpation above the kidney is not unusual and applied pressure may then result in a more abundant discharge from the vulva. Such a case is described by KAKUSCHKIN (cit. KILBANE). If the orifice of the ectopic ureter opens directly into the external sphincter, the patient often complains of painful micturition and possibly also of tenesmus. Diagnosis is difficult in such cases, as the opening cannot be seen. HOLM (1925) described one case in which the condition was discovered in a six-month-old girl at post-mortem examination.

Incontinence and infections of the urinary tract which resist therapy should bring to mind the possibility of an ectopic ureter. Diagnosis is not always easy but a detailed anamnesis may orient the direction of the investigations. Careful inspection of the vulva, vagina and urethra frequently discloses the orifice of the ectopic ureter, through which urine or pus may be expressed. In a number of cases an ectopic ureteric opening may be demonstrated when, despite filling the bladder with indigo carmine solution, unstained urine is obtained. By the intravenous injection of dye the urine from the ectopic ureter is stained if the kidney be able to concentrate that urine sufficiently. Roentgenologic examination following injection of a contrast medium through the opening of the ectopic ureter affords a complete demonstration of the anatomic conditions. This method together with urography have been the two most important aids up to the present in roentgenologic diagnosis. Due to parenchymal damage the excretion of contrast medium into the ectopic ureter is often impaired or entirely absent. In the lower part of the kidney, however, a kidney pelvis with more or less changed upper calyces is seen outlined.

In recent years abdominal aortography has gained increasing importance in the examination of the condition of the kidneys. By this means the arterial supply is made clear in detail and the condition of the parenchyma may be estimated in the filling phase with greater certainty than with other roentgenologic methods. Knowledge of the arterial supply facilitates the planning of eventual operation and provides valuable information concerning the extent to which partial renal resection is possible.

SUMMARY

A case of ectopic ureter with the orifice opening into the vestibule of the vagina in a 45-year-old woman is described. The embryology, pathology and symptomatology of the malformation is discussed. In addition to the current urologic methods of examination, the use of abdominal aortography is suggested. Its significance is indicated and illustrated by this case.

ZUSAMMENFASSUNG

Ein Fall mit ektopischem Urether bei einer 45-jährigen Frau wird beschrieben; das Orificium mündete hier in das Vestibulum vaginae. Die Embryologie, die Pathologie und die Symptomatologie dieser Missbildung wird diskutiert. Ausser den üblichen urologischen Untersuchungsmethoden wird die Anwendung der abdominalen Aortographie vorgeschlagen. Die Bedeutung dieser Methode wird hervorgehoben und durch einen Fall illustriert.

RÉSUMÉ

Présentation d'un cas d'uretère ectopique s'ouvrant dans le vestibule du vagin chez une femme de 45 ans. Etude embryologique, anatomo-pathologique et symptomatologique de cette malformation. Outre les méthodes courantes d'examen urologique, les auteurs suggèrent d'utiliser l'aortographie abdominale dont l'intérêt est démontré par le cas présenté.

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BOOK REVIEWS

MEDIZINISCHE RÖNTGENTECHNIK. I.: Medizinischer Teil (Skelettaufnahmen und Organuntersuchungen). Von H. Schoen. 224 Seiten, 476 Abb. Georg Thieme Verlag, Stuttgart 1951. DM 22.50.

The present work is intended for the training of technical assistants and chief stress is laid upon those routine positionings which are meant to be performed by the assistants themselves. Certain more complicated examinations, intended to be carried out by a physician, and depending on knowledge required, are discussed. More than half the book deals with skeletal views. The various positionings are as a rule illustrated with pictures of the posture of the patient, the appearances of the skeleton in the projection used, as well as roentgen films. The views which the author considers to be the best are described in detail, but there are also several others: some are only mentioned by the name of the originator, others are but briefly described. A great disadvantage of the text book is, however, that there is no bibliography. Thus anyone wanting to learn more about the description of a certain view may undoubtedly find out the name of the author but no information as to where or when the paper was published. The positions one ought to include in a text book like this, can, of course, be fairly subjective. As many special ones, which are without practical importance or only of historical interest nowadays, are mentioned, the critic may perhaps be allowed to point out what in his opinion is missing.

JÖNSSON's simple method of reproducing the sternum and costal ribs is not mentioned, neither are those views of the calcaneus which the reviewer for his part considers as absolutely necessary for an exact estimation of the course and position of most calcanear fractures, viz. those described by HALLGRIMSSON and BRODÉN. This book has the same fault as the majority of text books, namely that there is no description of how true lateral views of the spine should be obtained. Nothing is mentioned about the examination of instability. Further, there is no description included of the easy method of obtaining certain skeletal positionings through screening, for instance an axial view of the shoulder joint or the intervertebral foramina of the cervical spine. The latter are practically impossible to demonstrate without great difficulty if the projection is not adjusted with screening. As in most manuals similar to this, skull projections are not obtained by the use of the Lysholm skull table. However, the latter is mentioned and it is pointed out that it ought to be more widely employed than at present. To a large extent the projections of the skull described lack precision. The positions for the optic foramen which are described and illustrated appear to be of little value. In the film published the bone bridge between the optic foramen and superior orbital fissure, the situation where bone changes in the dorsal part of the orbit in most cases originate, is not shown.

The object of giving technical assistants an insight into the technique of other examinations will probably be attained, to a great extent, by the other descriptions in the book, and surely these may be of value even to those graduates who are considering taking up radiology. However, even here there are several gaps. A colon examination in which the investigator has not taken a true lateral view of the junction between the rectum and the sigmoid is not a complete examination in the reviewer's opinion, as that region often cannot be outlined in other projections. To discuss the oral hepato-lienographic

method of O. Olsson and Ekman seems rather unnecessary; up to now it has been used in experiments only in animals. It is a pity that the Swedish differentiation between urography and pyelography has not been universally accepted, the former referring to the method in which the contrast medium is injected intravenously, the latter to the method in which the contrast medium is injected in a retrograde direction through a catheter. Such a consistent nomenclature would make descriptions in the literature of the roentgen diagnosis of the urogenital system clearer.

The technical description of urography, as in many text books, is not satisfactory. The investigation of the female urethra is missing. Too little space in the book has been devoted to retroperitoneal pneumography following presacral gas inflation, likewise to aortography. The references to encephalography and myelography are unfortunate. It is stated that Perabrodil may be used in myelography, which obviously means subarachnoidal myelography. Cases with fatal outcome in which Perabrodil has accidentally entered the subarachnoidal space, have been described, however, in the literature, and caution has therefore been given against its employment. On the other hand, Abrodil may, under certain circumstances, be used. This however, is not mentioned. The reviewer certainly agrees with the author that negative contrast media must be used in myelography in the first place, although it is of no value to perform a myelographic examination with a negative contrast medium in the way described. With great satisfaction the reviewer learns that in the author's opinion only a water-soluble contrast medium should be used in bronchography.

The book ends with a summary of various contrast methods. The designation of the contrast media is hardly suitable. As a contrast medium for cholecystography, urography as well as angiography (referred to by the author as vasography) "Jodstoffe" is mentioned. It is quite true that the contrast media employed contain iodine, but in any case there is an essential difference between those which are used in these various examinations.

In spite of all the criticisms levelled, this text book is one of the better ones the reviewer has read.

E. Lindgren.

Les syndromes douloureux de la région épigastrique, Tome I et II. Par René A. Gutmann, 5e Edition revue et corrigée. G. Doin & Cie, Editeurs, Paris 1951—1952.

This already classical book is to a great extent roentgen diagnostic. In the preface the author aggressively rejects the use of statistics in clinical medicine. He may expect therefore to be badly judged in certain countries. Those who proceed from the preface to the contents will however be unable to pass unfavourable judgement. The two volumes contain an impressive mass of information on the diseases giving rise to epigastric pain, communicated in that literary, readable and somewhat prolix style which is often typical of French medical literature. It is clear that Dr. Gutmann masters the method used and furthermore possesses very extensive experience.

Åke Lindbom.

Injury of the Xiphoid. By Michael Burman and Samuel E. Sinberg. 92 pp., 18 illustrations. Columbia University Press, New York 1952, $ 3.50.

It is surprising that a book can be written on such a limited subject. The authors probably know more than any other living persons about injuries of the xiphoid process. Others, however, have certainly produced better roentgenograms of this bone. The book may not be a best seller, but those seeking information on the steering wheel fracture and other injuries of the xiphoid process should read it.

Åke Lindbom.

DER GESUNDE UND DER KRANKE KEHLKOPF IM RÖNTGENBILD. Von C. R. Griebel. 170 Seiten, 156 Abb. Georg Thieme Verlag, Stuttgart 1952. DM 48.—

The paper begins with a short historical account, which is very incomplete. For instance, BACLESSE as well as the literature after 1938, seem to be unknown to the author. It is evident from a short chapter headed "Technik" that roentgenologic technique is something which is unfamiliar to the writer. Later on the normal lateral appearances of the larynx and its anatomic variations are discussed. The main part of the paper consists of short case reports on different pathologic conditions, illustrated by lateral views of the larynx. The illustrations are, as in most German books, very good.

The author states: "Warum sich das Kehlkopfröntgenbild bei den Laryngologen doch nicht so durchgesetzt hat ..... lag einmal darin, dass man allein dem Röntgenologen das Feld überliess ....." If one were to insist that laryngoscopic examinations must not be left to the laryngoscopists, but be performed by roentgenologists, the author would certainly object — and rightfully so. This work is an illustration of the fact that in certain countries it appears that a clinician without knowledge of roentgen diagnosis is considered capable of publishing papers on roentgenologic subjects.

E. Lindgren.

BOOKS RECEIVED

We acknowledge with thanks under this heading books received for review, which we trust will be regarded as a sufficient mark of appreciation of the courtesy of the sender. The reviews of selected items will appear as soon as opportunity affords.

MEDIZINISCHE RÖNTGENTECHNIK. II. Physikalisch-technischer Teil. Von H. Schoen unter Mitarbeit von E. Bunde, V. Loeck and W. Frommhold. Georg Thieme Verlag, Stuttgart 1952.

LEHRBUCH DER RÖNTGENOLOGISCHEN DIFFERENTIALDIAGNOSTIK. Band I: Erkrankungen der Brustorgane. Von Werner Teschendorf. 3e Aufl. Georg Thieme Verlag, Stuttgart 1952.

DIE FRÜHDIAGNOSE DES UTERUSCARCINOMS. Histologie, Kolposkopie, Cytologie, biochemische Methoden. Von Hans Limburg. Georg Thieme Verlag, Stuttgart 1952.

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